BIOLOGICAL EVALUATION FOR FEDERALLY ENDANGERED AND THREATENED CANADA LYNX, NORTHERN LONG-EARED BAT, PIPING PLOVER, RED KNOT, ROSEATE TERN, FURBISH'S LOUSEWORT, EASTERN PRAIRIE FRINGED ORCHID, AND ATLANTIC SALMON IN MAINE:

An evaluation of the potential effects of state-adopted ammonia and cadmium aquatic life criteria

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Introduction

Federally protected species are listed as endangered or threatened under the Endangered Species Act (ESA). Section 7(a) of the Endangered Species Act of 1973 (ESA), as amended, grants authority to and imposes requirements upon Federal agencies regarding endangered or threatened species of fish, wildlife, or plants ("listed species") and habitat of such species that has been designated as critical (a "critical habitat"). The ESA requires every Federal agency, in consultation with, and with the assistance of the Secretary of Interior, to ensure that any action it authorizes, funds, or carries out, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The United States Fish and Wildlife Service (USFWS) administers Section 7 consultations for freshwater species.

On February 6, 2020, Maine's Board of Environmental Protection (BEP) adopted revisions to Chapter 584 of DEP's regulations (Surface Water Quality Criteria for Toxic Pollutants), and they took effect on February 16, 2020. Maine Department of Environmental Protection (DEP) submitted them to EPA on April 24, 2020. They included, among other water quality standards, draft revised Statewide aquatic life criteria for ammonia and cadmium (Cd) applicable to waters under the state of Maine's jurisdiction. The criteria can be found at the following link: https://www.maine.gov/dep/water/wqs/index.html.

EPA proposes to approve Maine's revised aquatic life criteria. The purpose of this Biological Evaluation (BE) is to evaluate the potential effects that EPA's approval of the criteria may have on federally protected species, specifically the Canada lynx (*Lynx canadensis*), Northern long-eared bat (*Myotis septentrionalis*), piping plover (*Charadrius melodus melodus*), red knot (*Calidris canutus rufa*), roseate tern (*Sterna dougallii dougallii)*, Furbish's lousewort (*Pedicularis furbishiae*), Eastern prairie fringed orchid (*Platanthera leucophaea*), and Atlantic salmon (*Salmo salar*). This BE addresses the proposed approval in compliance with Section 7(c) of the ESA of 1973, as amended. Section 7 of the ESA assures that, through consultation (or conferencing for proposed species) with the USFWS, federal actions do not jeopardize the continued existence of any threatened, endangered or proposed species, or result in the destruction or adverse modification of critical habitat. For the reasons set forth below, EPA believes that EPA's approval of Maine's aquatic life criteria is not likely to adversely affect the eight listed freshwater, anadromous, and terrestrial species.

Project Description

Background

The adopted revisions to Chapter 584 of DEP's regulations (Surface Water Quality Criteria for Toxic Pollutants), include revised statewide criteria for ammonia and cadmium criteria for aquatic life use (ME DEP 2020). If approved by EPA, the criteria will be effective for all Clean Water Act purposes, including being the applicable instream criteria to protect aquatic life uses in Maine's waters. Consistent with its obligations under the Endangered Species Act, EPA Region 1 is consulting with the USFWS and NOAA Fisheries on the revised aquatic life criteria in advance of approving them. This Biological Evaluation addresses whether EPA's approval of the State's revised criteria is likely or unlikely to adversely affect listed freshwater, anadromous, marine and terrestrial endangered species in Maine.

Action Area

The action area is defined in 50 CFR 402.02 as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For purposes of this Section 7 consultation support document, the extent and location of the Action Areas in Maine are defined as:

1.) All of the State of Maine for the Northern long-eared bat;
2.) A block of the northern half of the State for the Canada lynx; (Also, the Designated Critical Habitat for the Canada lynx, see below.)
3.) A block of the northeast portion of the State for the Eastern prairie fringed orchid;
4.) The upper stretch of the St. John's River for Furbish's lousewort;
5.) Maine coastal lands and beaches, and coastal waters for the piping plover, red knot, and roseate tern; and
6.) Large portions of the southern two thirds of the State for the Atlantic salmon. (Also, the Designated Critical Habitat for the Atlantic salmon, see below.)

The maps included in this BE (maps 1-4, below) illustrate the location within Maine waters of the estimated range of Canada lynx, Furbish's lousewort, Eastern prairie fringed orchid, and Atlantic salmon, respectively (USFWS 2020).

Listed Species, Distinct Population Segments and Critical Habitat Within the Action Area

There is one endangered species of salmon listed under the Endangered Species Act that occurs or has the potential to occur in the action area and may be affected by the proposed action. One species of threatened lynx, one species of endangered plant and one species of threatened plant, two species of threatened shore birds and one species of endangered shore bird, and one species of threatened bat also occur in the action area. The pertinent listing information for the species is identified in Tables 1-1 through 1-8, below.

Table 1-1. Federal Register Notices Related to the Canada lynx (*Lynx canadensis*)
Status – Threatened

Title	Federal Register	Date
Revised Designation of Critical Habitat for the Contiguous United States Distinct Population Segment of the Canada Lynx and Revised Distinct Population Segment Boundary; Final Rule	79 FR 54781 54846	09/12/2014
Revised Designation of Critical Habitat for the Contiguous U.S. Distinct Population Segment of the Canada Lynx and Revised Distinct Population Segment Boundary; Proposed Rule	78 FR 59429 59474	09/26/2013

Endangered and Threatened Wildlife and Plants; Clarification of Significant Portion of the Range for the Contiguous United States Distinct Population Segment of the Canada Lynx	72 FR 1186 1189	01/10/2007
Designation of Critical Habitat for the Contiguous United States Distinct Population Segment of the Canada Lynx: Proposed rule; reopening of public comment period, notice of availability of draft economic analysis and draft environmental Assessment, and amended Required Determinations.	71 FR 53355 53361	09/11/2006
Endangered and Threatened Wildlife and Plants; Proposed Designation of Critical Habitat for the Contiguous United States Distinct Population Segment of the Canada Lynx; Proposed Rule	70 FR 68294 68328	11/09/2005
Endangered and Threatened Wildlife and Plants; Notice of Remanded Determination of Status for the Contiguous United States Distinct Population Segment of the Canada Lynx; Clarification of Findings; Final Rule	68 FR 40076 40101	07/03/2003
Endangered and Threatened Wildlife and Plants; Reopening of Comment Period for Final Rule To List the Contiguous United States Distinct Population Segment of the Canada Lynx	68 FR 12611 12612	03/17/2003
Determination of Threatened Status for the Contiguous U.S. Distinct Population Segment of the Canada Lynx and Related Rule; Final Rule	65 FR 16053 16086	03/24/2000
ETWP; Proposal To List the Contiguous United States Distinct Population Segment of the Canada Lynx; Proposed Rule	63 FR 36994 37013	07/08/1998

Table 1-2. Federal Register Notices Related to the Northern Long-Eared Bat (*Myotis septentrionalis*)
Status - Threatened

Title	Federal Register	Date
90-Day Finding on a Petition To List the Eastern Small-Footed Bat and the Northern Long-Eared Bat as Threatened or Endangered	76 FR 38095 38106	06/29/2011
12-Month Finding on a Petition To List the Eastern Small-Footed Bat and the Northern Long-Eared Bat as Endangered or Threatened Species; Listing the Northern Long-Eared Bat as an Endangered Species; Proposed Rule	78 FR 61045 61080	10/02/2013
Listing the Northern Long-Eared Bat as an Endangered Species	78 FR 72058 72059	12/02/2013

6-Month Extension of Final Determination on the Proposed Endangered Status for the Northern Long-Eared Bat	79 FR 36698 36699	06/30/2014
Endangered Species Status for the Northern Long-Eared Bat: Reopening of comment period	79 FR 68657 68659	11/18/2014
Listing the Northern Long-Eared Bat With a Rule Under Section 4(d) of the Act	80 FR 2371 2378	01/16/2015
Listing the Northern Long-Eared Bat With a Rule Under Section 4(d) of the Act; Correction	80 FR 5079	01/30/2015
Threatened Species Status for the Northern Long-Eared Bat With 4(d) Rule	80 FR 17973 18033	04/02/2015
4(d) Rule for the Northern Long-Eared Bat; Final rule	81 FR 1900 1922	01/14/2016
Determination That Designation of Critical Habitat Is Not Prudent for the Northern Long-Eared Bat: Critical habitat determination.	81 FR 24707 24714	04/27/2016
Draft Environmental Assessment, Draft Habitat Conservation Plan, and Draft Implementing Agreement; Receipt of an Application for an Incidental Take Permit, Wildcat Wind Farm, Madison and Tipton Counties, Indiana	81 FR 39947	06/20/2016

Table 1-3. Federal Register Notices Related to the Furbish's lousewort (*Pedicularis furbishiae*)
Status - Endangered

Title	Federal Register	Date
21 Draft Recovery Plan Revisions for 25 Species in 15 States Across the United States; Notice of Availability	84 FR 38288 38291	08/06/2019
Initiation of 5-Year Reviews of 19 Northeastern Species	83 FR 39113 39115	08/08/2018
Initiation of 5-Year Reviews of Five Listed Species: Delmarva Peninsula Fox Squirrel, Northeastern Bulrush, Furbish Lousewort, Chittenango Ovate Amber Snail, and Virginia Round-Leaf Birch	75 FR 47025 47026	08/04/2010
90-Day Finding on a Petition To Delist Pedicularis furbishiae (Furbish lousewort) and Initiation of a 5-Year Status Review	70 FR 46467 46470	08/10/2005
Final Determination that Eleven Plant Taxa are Endangered and Two Plant Taxa are Threatened Species	43 FR 17910 179??	04/26/1978

Proposed Endangered Status for 1700 U.S. Plants; 41 FR 24523 24572	41 FR 24523 24572	06/16/1976

Table 1-4. Federal Register Notices Related to the Eastern prairie fringed orchid (*Platanthera leucophaea*)
Status - Threatened

Title	Federal Register	Date
5-Year Status Reviews of Seven Listed Species; Notice of initiation of reviews and request for information8	77 FR 38762 38764	06/29/2012
ETWP; Determination of Threatened Status for Eastern and Western Prairie Fringed Orchids; 54 FR 39857 39863	54 FR 39857 39863	09/28/1989
Proposal to Determine Platanthera leucophaea (Eastern Prairie Fringed Orchid) & Plantanthera praeclara (Western Prairie Fringed Orchid) to be Thr. Species; 53 FR 39621-39626	53 FR 39621 39626	10/11/1988

Table 1-5. Federal Register Notices Related to the Piping Plover (*Charadrius melodus melodus*)
Status – Threatened (Atlantic Coast)

Title	Federal Register	Date
Initiation of 5-Year Status Reviews of Nine Listed Animal and Two Listed Plant Species	79 FR 38560 38562	07/08/2014
Endangered and Threatened Wildlife and Plants; 5-Year Review - Notice of initiation of review; request for information on the piping plover (Charadrius melodus).	73 FR 56860 56862	09/30/2008
Piping Plover Atlantic Coast Population Revised Recovery Plan		05/02/1996
Piping Plover (Charadrius melodus) 5-Year Review		09/29/2009

Table 1-6. Federal Register Notices Related to the Red Knot (Calidris canutus rufa)
Status - Threatened

Title	Federal Register	Date
Threatened Species Status for the Rufa Red Knot	79 FR 73705 73748	12/11/2014
Proposed Threatened Status for the Rufa Red Knot (Calidris canutus rufa)	79 FR 27548 27550	05/14/2014

Proposed Threatened Status for the Rufa Red Knot (Calidris canutus rufa)	79 FR 18869 18870	04/04/2014
Proposed Threatened Status for the Rufa Red Knot (Calidris canutus rufa); Proposed Rule	78 FR 60023 60098	09/30/2013
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions	77 FR 69993 70060	11/21/2012
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions	76 FR 66370 66439	10/26/2011
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule	75 FR 69222 69294	11/10/2010
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions	74 FR 57804 57878	11/09/2009
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule	73 FR 75176 75244	12/10/2008
Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule	72 FR 69034 69106	12/06/2007
Review of Native Species That Are Candidates or Proposed for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions	71 FR 53756 53835	09/12/2006

Table 1-7. Federal Register Notices Related to the Roseate Tern (Sterna dougallii dougallii) Status – Endangered (Atlantic Coast south to N.C.)

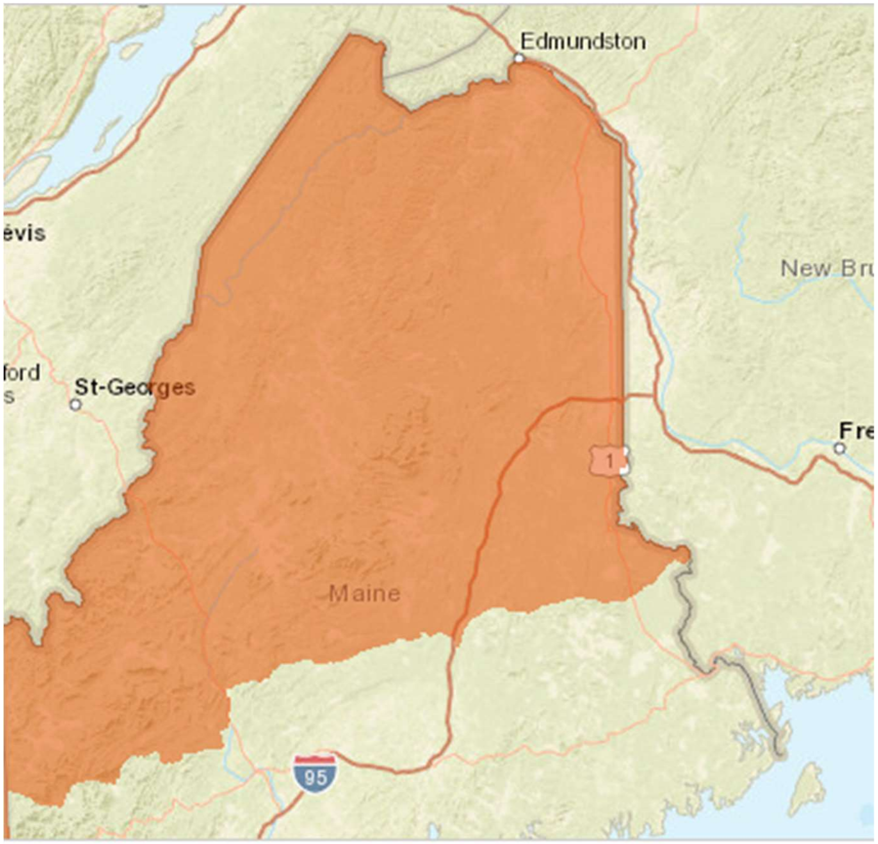
Title	Federal Register	Date
Initiation of 5-Year Reviews of 19 Northeastern Species	83 FR 39113 39115	08/08/2018
5-Year Status Review of Roseate Tern; request for information; clarification	75 FR 17153 17154	04/05/2010
Initiation of 5-Year Reviews of 7 Listed Species: Notice of review; request for information	73 FR 76373 76375	12/16/2008
Determination of Endangered and Threatened Status for 2 Populations of Roseate Tern; 52 FR 42064-42068	52 FR 42064 42068	11/02/1987
Proposed Endangered and Threatened Status for 2 Populations of Roseate Tern; 51 FR 40047-40051	51 FR 40047 40051	11/04/1986
Review of Vertebrate Wildlife for Listing as End. or Thr. Species	47 FR 58454 58460	12/30/1982

Table 1-8. Federal Register Notices Related to the Atlantic salmon (Salmo salar) Status – Endangered (Atlantic Coast south to N.C.)

Title	Federal Register	Date
Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon (Salmo salar)		01/31/2019
Endangered and Threatened Wildlife and Plants; Draft Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon	81 FR 18639	03/31/2016
Designation of Critical Habitat for Atlantic Salmon (Salmo salar) Gulf of Maine Distinct Population Segment; Final Rule	74 FR 29300 29341	06/19/2009
Determination of Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic Salmon; Final Rule	74 FR 29344 29387	06/19/2009
Proposed Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic Salmon;12-month petition finding	73 FR 51415 51436	09/03/2008
90-Day Finding for a Petition to List the Kennebec River Population of Anadromous Atlantic Salmon as Part of the Endangered Gulf Of Maine Distinct Population Segment	71 FR 66298 66301	11/14/2006

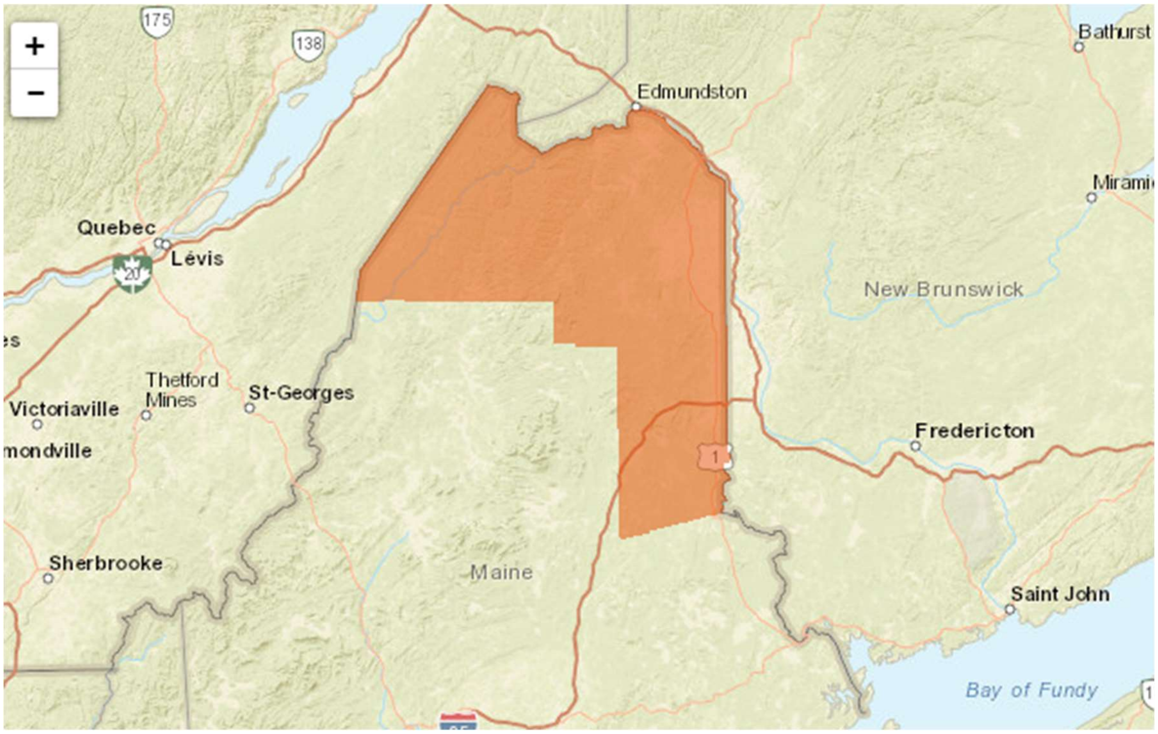
Notice of Availability for the Final Recovery Plan for the Gulf of Maine Distinct Population Segment of Atlantic Salmon	70 FR 75473 75478	12/20/2005
Notice of Availability of a Draft Recovery Plan for the Gulf of Maine Distinct Population Segment (DPS) of Atlantic Salmon	69 FR 34184 34185	06/18/2004
Endangered and Threatened Species; Final Endangered Status for a Distinct Population Segment of Anadromous Atlantic Salmon (Salmo salar)in the Gulf of Maine	65 FR 69459 69483	11/17/2000
ETWP; Extension of Comment Period and Notice of Public Hearings on Proposed Endangered Status for a Distinct Population Segment of Anadromous Atlantic Salmon (Salmo salar) in the Gulf of Maine	65 FR 1082 1083	01/07/2000
Endangered and Threatened Species; Proposed Endangered Status for a Distinct Population Segment of Anadromous Atlantic Salmon (Salmo salar) in the Gulf of Maine	64 FR 62627 62641	11/17/1999
Availability of a Status Review of the Atlantic Salmon in the Gulf of Maine Distinct Population Segment	64 FR 56297 56298	10/19/1999
ETWP; Proposed Threatened Status for a Distinct Population Segment of Anadromous Atlantic Salmon (Salmo salar) in Seven Maine Rivers	60 FR 50530 50539	09/29/1995
ETWP; 12 Month Finding for a Petition to List the Anadromous Atlantic Salmon (Salmo Salar) Populations in the United States as Endangered or Threatened	60 FR 14410 14412	03/17/1995
ETWP; 90-Day Finding for a Petition to List the Anadromous Atlantic Salmon (Salmo salar) Populations in the United States as Endangered or Threatened	59 FR 3067 3069	01/20/1994

Map 1. Estimated Range of Canada lynx in Maine (US FWS 2020)

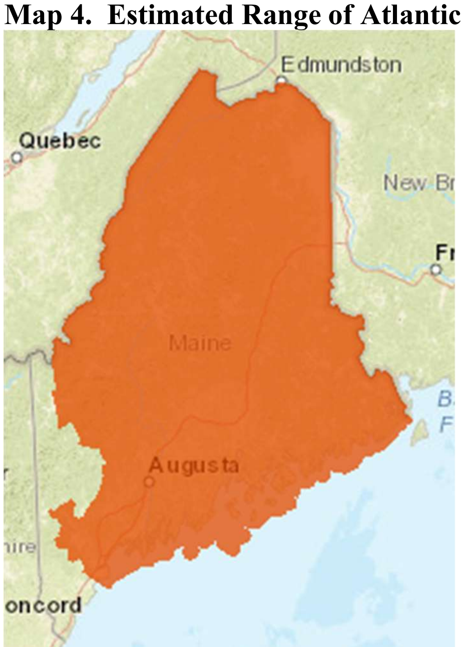


Map 2. Estimated Range of Furbish's lousewort in the headwaters of the St. John's River in Maine (US FWS 2020)

Map 3. Estimated Range of Eastern prairie fringed orchid in Maine (US FWS 2020)



Map 4. Estimated Range of Atlantic salmon in Maine. (US FWS 2020)



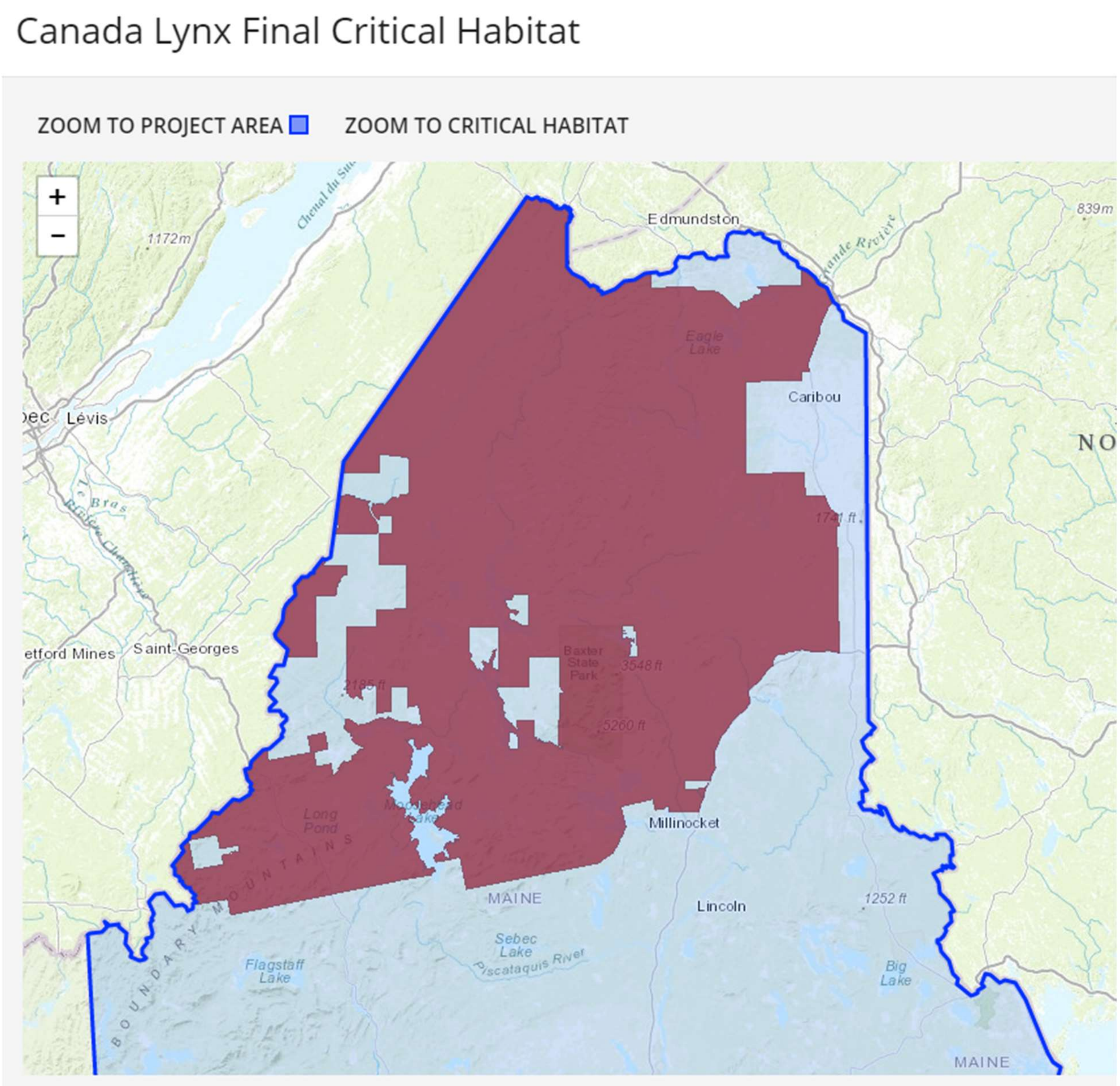
Critical Habitat

There is Designated Critical Habitat for Canada lynx in the northern half of the State of Maine (see Figure 1, below). Table 1-9 shows the Canada lynx life stages expected where the action area overlaps the lynx's Critical Habitat (USFWS 2020).

Table 1-9. Canada lynx life stages and activities expected in the Critical Habitat in Maine waters.

Life Stage	Activity
Adult	Foraging, raising
Kittens	Foraging

Figure 1. Designated Critical Habitat for Canada lynx in northern Maine. (US FWS 2020a)

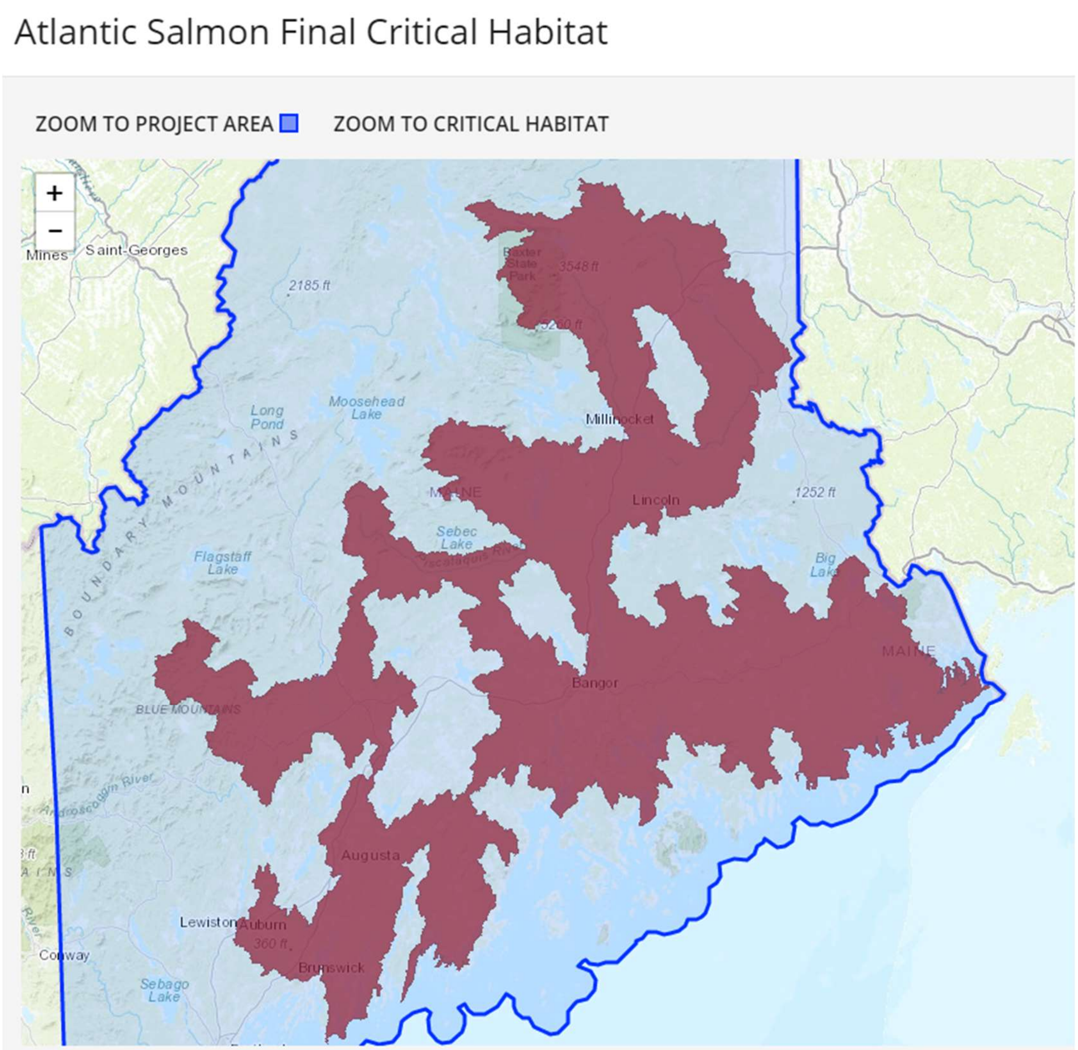


There is Designated Critical Habitat for the Atlantic salmon in the Penobscot River, Merrymeeting Bay, and Downeast coastal basins (see Figure 2, below). Table 1-10 shows the Atlantic salmon life stages expected where the action area overlaps the salmon's Critical Habitat (NOAA 2020).

Table 1-10. Atlantic salmon life stages and activities expected in the Critical Habitat in Maine waters.

Life Stage	Activity
Eggs	(Growing)
Alevins (hatchlings)	Migrating, foraging, rearing
Fry	Migrating, foraging, rearing
Parr	Migrating, foraging, rearing
Smolts	Migrating, foraging
Adult	Migrating, foraging, spawning

Figure 2. Designated Critical Habitat for Atlantic salmon in Maine waters. (US FWS 2020a)



Stressor Sources

Ammonia

Ammonia is considered highly toxic and is ubiquitous in surface water systems (Russo 1985, USEPA 2013). Ammonia is produced for commercial fertilizers and other industrial applications (Appl 1999). Ammonia also has numerous industrial applications, including as a protective atmosphere and as a source of hydrogen in metal finishing and treating applications (e.g., nitriding; Appl 1999). It is used in the chemical industry, including the production of pharmaceuticals (Karolyi 1968) and dyes (Appl 1999); and the petroleum industry uses ammonia for processing of crude oil and in corrosion protection (U.S. EPA 2004). Ammonia is also used in the mining industry for metals extraction (U.S. EPA 2004).

Natural sources of ammonia include the decomposition or breakdown of organic waste matter, gas exchange with the atmosphere, forest fires, animal waste, the discharge of ammonia by biota, and nitrogen fixation processes (Environment Canada 1997; Environment Canada 2010; Geadah 1985).

Cadmium

Cadmium is a naturally occurring metal found in mineral deposits and distributed widely at low concentrations in the environment (USEPA 2016). The primary current industrial uses of cadmium are for manufacturing batteries, pigments, plastic stabilizers, metal coatings, alloys and electronics, and in the manufacture of nanoparticles (Fulkerson and Goeller 1973; Hutton 1983; Pickering and Gast 1972; Wilson 1988). Cadmium is also present in mine wastes, fossil fuels, iron and steel, cement, and fertilizers (Cook and Morrow 1995). The agricultural application of phosphorus fertilizers is one of the main sources of cadmium to the environment (Pan et al. 2010; Panagapko 2007). Cadmium also enters the environment as a result of weathering and erosion of rock and soils and natural combustion of volcanoes and forest fires (Hem 1992; Hutton 1983; Pickering and Gast 1972; Shevchenkl et al. 2003; USEPA 2016a; WHO 2010).

Mode of Action and Toxicity

Ammonia

Ammonia is unique among regulated pollutants because it is an endogenously produced toxicant that organisms have developed various strategies to excrete, which is in large part by passive diffusion of unionized ammonia from internal organs, such as the gills in fish (USEPA 2013). High external unionized ammonia concentrations reduce or reverse diffusive gradients and cause the buildup of ammonia in internal tissues and blood. Unionized ammonia may cause toxicity to *Nitrosomonas* spp. and *Nitrobacter* spp. bacteria, inhibiting the nitrification process (Russo 1985). Bacterial inhibition can result in the increased accumulation of ammonia in the aquatic environment, thereby intensifying the toxicity to beneficial bacteria and aquatic animals (Russo 1985).

The toxic action of unionized ammonia on aquatic animals, particularly in sensitive fish, may be due to one or more of the following causes: (1) proliferation in gill tissues, increased ventilation rates and damage to the gill epithelium (Lang et al. 1987); (2) reduction in blood-oxygen carrying capacity due to progressive acidosis (Russo 1985); (3) uncoupling oxidative phosphorylation causing inhibition of production and depletion of adenosine triphosphate (ATP) in the brain (Camargo and Alonso 2006); (4) and the disruption of osmoregulatory and circulatory activity disrupting normal metabolic functioning of the liver and kidneys (Arillo et. al.1981; Tomasso et al. 1980).

Among invertebrates, studies testing ammonia toxicity to bivalves, and particularly studies with freshwater mussels in the family Unionidae, have demonstrated their sensitivity to ammonia (Augspurger et al. 2003; Wang et al. 2007a, b; Wang et al. 2008). Toxic effects of unionized ammonia to both freshwater and marine bivalves include reduced opening of valves for respiration and feeding (Epifanio and Srna 1975); impaired secretion of the byssus, or anchoring threads in bivalves (Reddy and Menon 1979); reduced ciliary action in bivalves (USEPA 1985a); depletion of lipid and carbohydrate stores leading to metabolic alteration (Chetty and Indira 1995) as well as mortality (Goudreau et al. 1993). These negative physiological effects may lead to reductions in feeding, fecundity, and survivorship, resulting in decreased bivalve populations (Alonso and Camargo 2004; Constable et al. 2003).

Cadmium

Cadmium is a non-essential metal (NRC 2005) with no biological function in aquatic animals (Eisler 1985; Lee et al. 1995; McGeer et al. 2012; Price and Morel 1990; Shanker 2008; USEPA 2016). In one study comparing the acute toxicity of all 63 atomically stable heavy metals in the periodic table, cadmium was found to be the most acutely toxic metal to the amphipod, *Hyalella azteca*, based on the results of seven-day acute aquatic toxicity tests (Borgmann et al. 2005). In addition to acute toxicity, cadmium is a known teratogen and carcinogen, is a probable mutagen, and is known to induce a variety of other short- and long-term adverse physiological effects in fish and wildlife at both the cellular and whole-animal level (ATSDR 2012; Eisler 1985; Okocha and Adedeji 2011). Chronic exposure leads to adverse effects on growth, reproduction, immune and endocrine systems, development, and behavior in aquatic organisms (McGeer et al. 2012). Other toxic effects include histopathologies of the gill, liver, and kidney in fish; renal tubular damage; alterations of free radical production and the antioxidant defense system; immunosuppression; and structural effects on invertebrate gills (Giari et al. 2007; Jarup et al. 1998; McGeer et al. 2011; Okocha and Adedeji 2011; Shanker 2008).

Toxic effects are thought to result from the free ionic form of cadmium (Goyer et al. 1989), which causes acute and chronic toxicity in aquatic organisms primarily by disrupting calcium homeostasis and causing oxidative damage. In freshwater fish, cadmium competes with calcium at high affinity binding sites in the gill membrane and blocks the uptake of calcium from water by interfering with ion uptake in specialized calcium channels that are located in the mitochondria-rich chloride cells (Carroll et al. 1979; Evans 1987; McGeer et al. 2012; Morel and Hering 1993; Pagenkopf 1983; Tan and Wang 2009). The combined effect of competition for the binding sites and blockage of calcium uptake on the gill membrane results in acute hypocalcaemia in freshwater fish, which is characterized by cadmium accumulation in tissues as well as decreased calcium concentrations in plasma (McGeer et al. 2011; Roch and Maly 1979; Wood et al. 1997). This mechanism is also thought to be the target of cadmium toxicity in marine fish (McGeer et al. 2012; Schlenk and Benson 2005), although cadmium is generally considered to be less toxic in sea water than in fresh water. The lesser sensitivity of marine fish and aquatic organisms in general may be both a function of physiology and environmental condition. Rocha et al. (2015) observed an increase in catalase activity (oxidative stress) in the marine mussel, *Mytilus galloprovincialis*, suggesting a possible mode of action for this taxon. Mebane et al. (2006), for example, suggests the energy demands for fish to maintain homeostasis in the lower ionic composition freshwater environment may make fish more sensitive to metals, such as cadmium, which inhibit ion regulation. Higher levels of calcium and chloride in seawater are also believed to compete to a greater degree with cadmium, potentially making it less bioavailable to aquatic life (Engel and Flower 1979). However, application of the calcium competition for apical entry and the subsequent osmoregulatory disturbance toxicity mechanism for insects has been questioned by Poteat and Buchwalter (2013). Their research (Poteat et al. 2012, 2013) has demonstrated the lack of interaction between calcium and cadmium at the apical surface of aquatic insects in dissolved exposures. Cadmium exposure is also associated with the disruption of sodium balance and accompanying Na+/K+-ATPase activity (Atli and Canli 2007). Once inside the cell, cadmium can disrupt enzymatic function (Okocha and Adedeji 2011), by either directly affecting Ca-ATPase activity or inhibiting antioxidant processes. Cadmium also inhibits enzymes such as catalase, glutathione reductase, and superoxide dismutase and reducing agents such as GSH, ascorbate, b-carotene and a-tocopherol, all of which can lead to the generation of excess reactive oxygen species and reduced ATP production (McGeer et al. 2012).

Cadmium can bioaccumulate in aquatic organisms, with total uptake depending on the environmental cadmium concentration, exposure route, and the duration of exposure (Annabi et al. 2013; Francis et al. 2004; McGeer et al. 2000; Roméo et al. 1999). Cadmium concentrations typically build up in tissues at the site of exposure, such as the gill surface and gut tract wall (Chevreuil et al. 1995). Cadmium is then transferred via circulation to nearly all other tissues and organs, with the liver and kidney (in addition to the gill or gut) typically accumulating high concentrations relative to muscle tissues (Annabi et al. 2013; McGeer et al. 2012). Although cadmium bioaccumulates in some aquatic species, there does not appear to be a consistent relationship between body burden and toxicological effect. In a detailed review of this relationship, Mebane (2006) concluded that for both aquatic invertebrates and fish, tissue concentrations associated with adverse effects regularly overlap with tissue concentrations where no adverse effects were observed. This inconsistent relationship between whole body tissue concentration and effect may be related to specific organs and/or tissues within which the accumulation is occurring and which would not be accurately quantified by whole body tissue residue analysis, and/or to the metabolic bioavailability of cadmium in tissues. Detoxification mechanisms in aquatic organisms, including the formation and activation of antioxidants, metallothionein, glutathione, and heat shock proteins (McGeer et al. 2011), effectively sequester the metal in a detoxified form, thereby allowing the organism to accumulate elevated levels of cadmium before displaying a toxic response. While the amount of detoxified metal that an aquatic organism can accumulate is theoretically unlimited, an organism will only experience toxic effects once the concentration of metabolically available metal is exceeded (Mebane 2006; Rainbow 2002). Under natural conditions, most accumulated cadmium in tissues is expected to exist in the detoxified state, which may explain the poor relationship between toxic effect and whole body tissue residue concentrations of trace metals reported by Rainbow (2002) for aquatic invertebrates and fish. Mebane (2006) concluded that, although there were not adequate data to establish acceptable tissue effect concentrations for aquatic life, cadmium is unlikely to accumulate in tissue to levels that would result in adverse effects to aquatic invertebrates or fish at calculated chronic criterion concentrations. The evaluation of direct exposure effects to organisms via water is therefore considered more applicable to the development of criteria for aquatic life.

Mammals and avian wildlife could be exposed to cadmium while foraging in aquatic habitats or via the ingestion of prey that have bioaccumulated cadmium from the aquatic environment. Although few adverse effects to mammals and avian wildlife have been demonstrated from the presence of cadmium in the aquatic environment, a number of laboratory-based investigations have demonstrated a range of sublethal and lethal toxic effects, the majority of which are associated with chronic exposure (Burger 2007; Cooke and Johnson 1996; Eisler 1985; Furness 1996; Henson and Chedrese 2004). However, the biological integrity of aquatic systems is considered to be at greater risk from cadmium than terrestrial systems based on the greater sensitivity of aquatic organisms relative to birds and mammals (Burger 2007; Wren et al. 1995). Freshwater biota are the most sensitive to cadmium, marine organisms are generally considered to be more resistant than freshwater organisms, while mammals and birds are considered to be comparatively resistant to cadmium (Burger 2007; Eisler 1985). Based on this trend, criteria that are protective of aquatic life are also considered to be protective of mammalian and avian wildlife (including aquatic-dependent wildlife) and are accordingly the focus of this evaluation.

Environmental Fate

Ammonia

Ammonia can enter the aquatic environment via anthropogenic sources or discharges such as municipal effluent discharges, agricultural runoff, aquacultural systems, industrial processes, and natural sources such as nitrogen fixation and the excretion of nitrogenous wastes from animals (USEPA 2013).

Ammonia (NH_3) is formed in the natural environment by the fixation of atmospheric nitrogen and hydrogen by diazotrophic microbes, such as cyanobacteria (Latysheva et al. 2012). Decomposition of manure, dead plants and animals by bacteria in the aquatic and terrestrial environments produce ammonia and other ammonium compounds through conversion of nitrogen during decomposition of tissues in a process called ammonification (ATSDR 2004; Sylvia 2005). In the aquatic environment, ammonia is also produced and excreted by fish.

Cadmium

Upon entering the aquatic environment, cadmium is strongly adsorbed to clays, and humic and organic materials (Watson 1973), and these complexes are removed from the water column by precipitation (Lawrence et al. 1996). Once in sediments, it can be re-suspended in particulate form or can return to the water column in dissolved form following hydrolosis or via upwelling in coastal zones (Bewers et al. 1987; USEPA 1979; USEPA 2016).

Conceptual Model

Ammonia

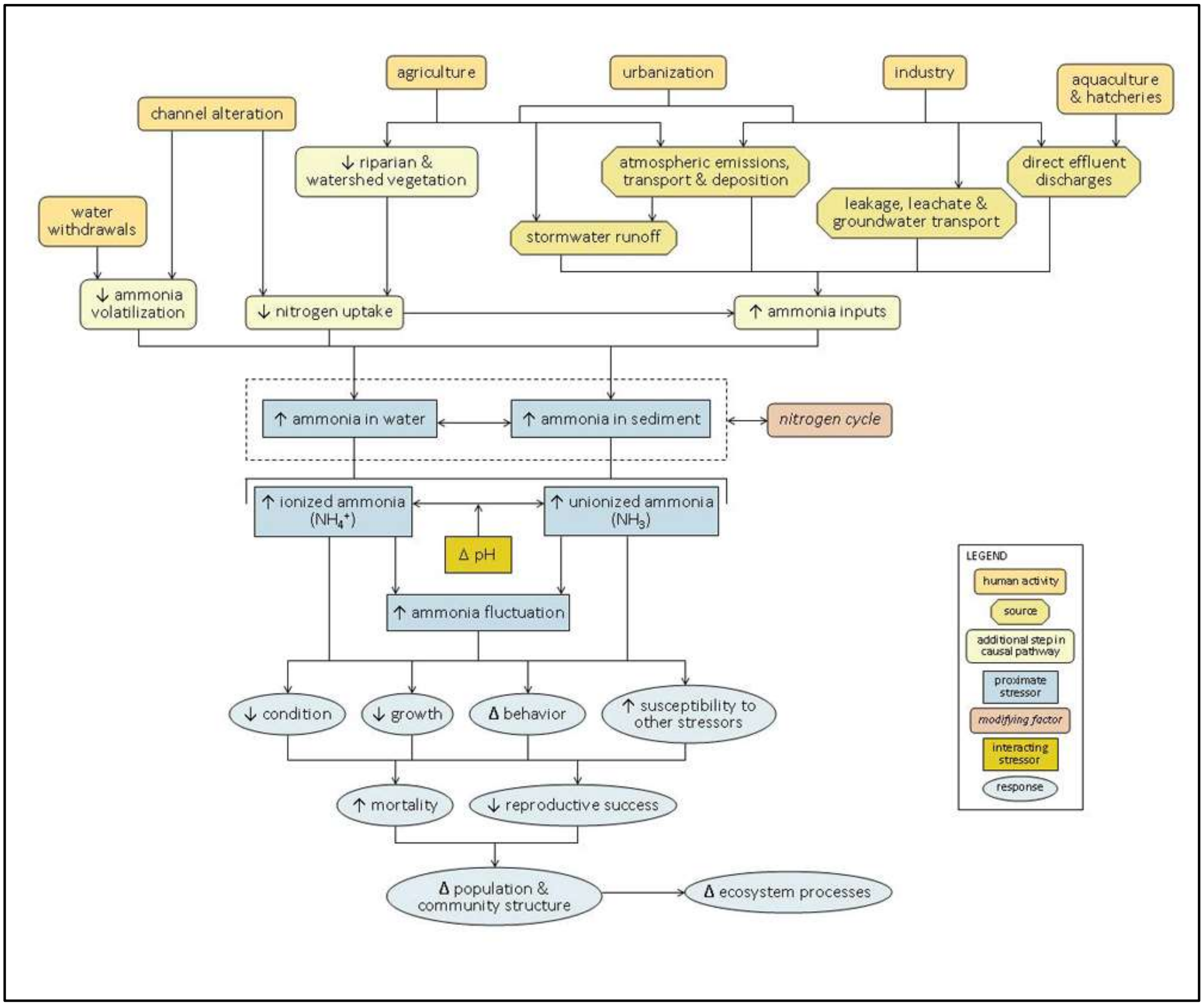


Figure 2. Conceptual Model Depicting the Major Sources, Transport and Exposure Media and Ecological Effects of Ammonia in the Environment. (EPA 2013)

Cadmium

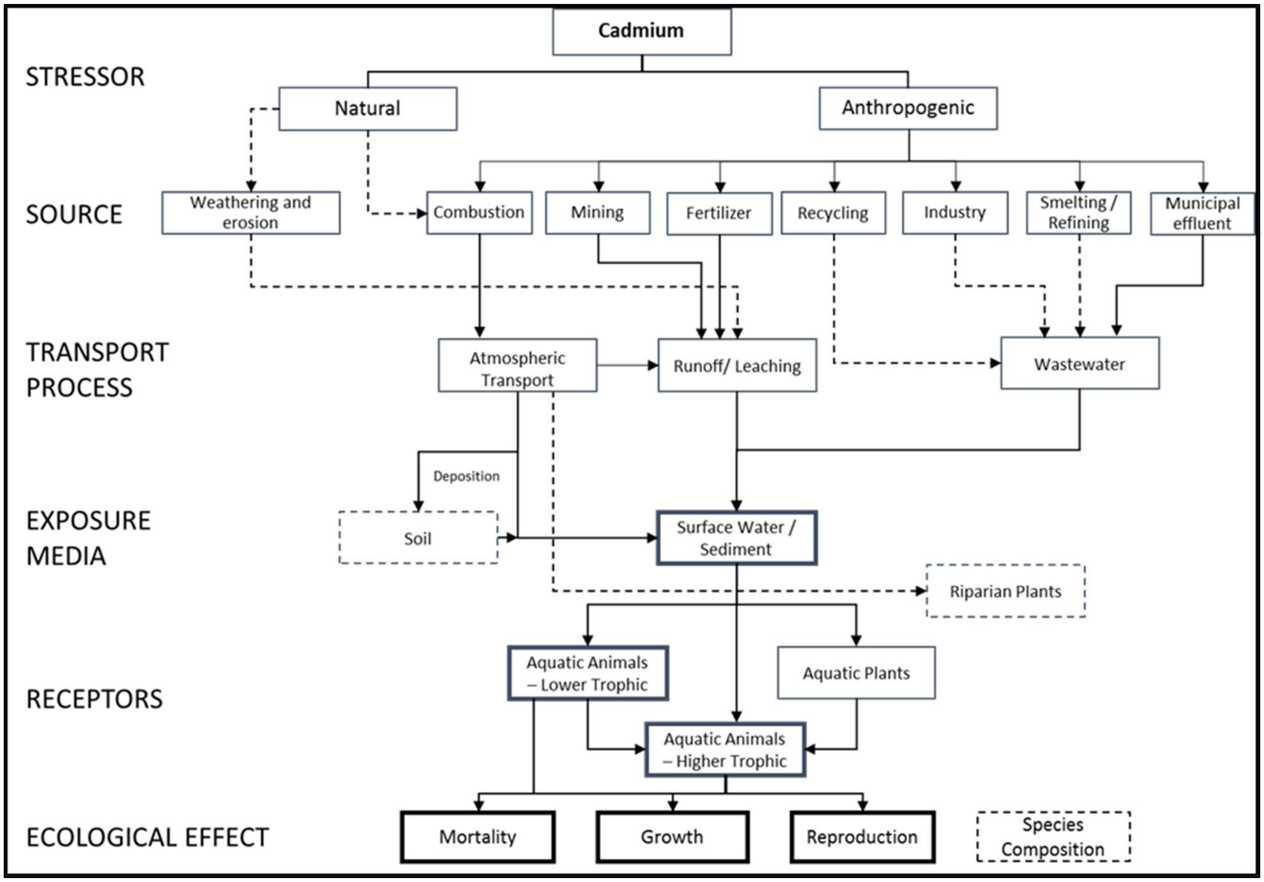


Figure 3. Conceptual Model Depicting the Major Sources, Transport and Exposure Media and Ecological Effects of Cadmium in the Environment. (Note: Solid line indicates potentially important pathway/media/receptor; dashed line indicates secondary pathway/media/receptor). **(EPA 2016)**

Criteria Analysis:

Ammonia Criteria for Fresh Waters

Maine adopted EPA's recommended freshwater ammonia aquatic life criteria from EPA's 2013 criteria update document, which reflects the latest scientific knowledge. Literature searches for laboratory toxicity tests of ammonia on freshwater aquatic life, published from 1985 to 2012, identified new studies containing acute and chronic toxicity data acceptable for criteria derivation. The acute criterion dataset includes 12 species of aquatic animals that are Federally-listed as threatened, endangered or species of concern. In the chronic criterion dataset for ammonia, Federally-listed species are represented by three salmonid fish species in the genus *Oncorhynchus*, including sockeye salmon, rainbow trout/steelhead, and the subspecies Lahontan cutthroat trout.

The dataset used to derive the 2013 ammonia criteria magnitudes included some threatened or endangered species, and EPA noted that none were the most sensitive of the species tested (USEPA 2013). The 2013 freshwater acute and chronic aquatic life criteria for ammonia will more fully protect the aquatic community than previous criteria.

The ammonia acute and chronic criteria magnitudes are affected by pH and temperature. For example, at pH of 7 and temperature of 20°C, the 2013 acute criterion magnitude is 17 mg TAN/L and the chronic criterion magnitude is 1.9 mg TAN/L. At this pH and temperature, the 2013 chronic criterion magnitude is 2.4-fold lower than the 1999 chronic criterion magnitude.

The acute criterion duration represents a one-hour average. The chronic criterion duration represents a 30-day rolling average with the additional restriction that the highest 4-day average within the 30 days be no greater than 2.5 times the chronic criterion magnitude. These values are not to be exceeded more than once in 3 years on average.

Cadmium Criteria for Fresh Waters

Maine adopted EPA's recommended cadmium criteria from EPA's March 2016 criteria document, which takes into account scientific data on acute and chronic toxicity made available since the 2001 criteria update, including toxicity data related to hardness, which continues to be the major quantitative correlation used to modify metal toxicity estimates in fresh water.

The acute criterion duration represents a one-hour average. The chronic criterion duration represents a 30-day rolling average with the additional restriction that the highest 4-day average within the 30 days be no greater than 2.5 times the chronic criterion magnitude. These values are not to be exceeded more than once in 3 years on average (USEPA 2016).

1. Effect Assessment Methodologies

The effects assessment methodology is explained in Appendix A, attached.

2 Ammonia Effects Assessment

2.1 Canada lynx (Lynx canadensis)

2.1.1 Canada Lynx Ammonia Effects Assessment: Freshwater

EPA's BE for the Canada lynx focuses below on the effects that the ammonia criteria could cause due to ingesting potentially contaminated drinking water. Because the lynx do not live in the water, EPA concludes there will be no effects as a result of meaningful residential exposure. Because the lynx' prey are all terrestrial species, EPA concludes there will be no effects as a result of meaningful prey exposure.

Lynx may ingest ammonia through drinking water; however, this is not considered to be a meaningful route of exposure to elicit adverse effects in lynx because the ammonia criteria are based on water-column exposures where the most sensitive route of exposure occurs at the gills, which does not apply to terrestrial species. Adverse effects typically result from an imbalance between internal and external ammonia concentrations. Ammonia is produced naturally in internal tissues, and organisms have natural mechanisms for excreting ammonia. Ammonia ingested by lynx will be excreted through natural mechanisms (e.g., urine). Ammonia becomes toxic when the surrounding environment contains a high enough level that excretion mechanisms must work against a gradient that results in the organism being unable to excrete the excess ammonia (EPA 2013). This situation does not apply to terrestrial species which are not surrounded by environmental ammonia.

Therefore, EPA finds that its approval of Maine's freshwater ammonia standards will have No Effect (NE) on the Canada lynx by ingesting drinking water. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from ingesting drinking water to the lynx are insignificant.

2.2 Northern Long-Eared Bat (*Myotis septentrionalis*)

2.2.1 Northern Long-Eared Bat Ammonia Effects Assessment: Freshwater

EPA's BE for the Northern long-eared bat focuses below on the effects that the ammonia criteria could cause due to ingesting potentially contaminated prey. Because the bats do not live in the water, EPA concludes there will be no effects as a result of meaningful residential exposure.

Bats consume some combination of terrestrial and aquatic insects. Studies indicate that the Northern long-eared bat (*Myotis septentrionalis*) prefers terrestrial over aquatic insects and prefers to forage in woodland over riparian areas when available (Sparks et al 2005, USEPA 2016). Lepidopterans and Coleopterans (beetles), primarily terrestrial species, make up the majority of the diet of the Northern long-eared bat (Brack and Whitaker 2001, Feldhammer et al 2009, Lee and McCracken 2004, Whitaker 2004).

The Northern long-eared bat relies in part on emergent aquatic insects as a dietary resource and may be affected if ammonia, at water column concentrations specified by the acute or chronic criteria magnitude and duration, were to adversely affect a large portion of emergent aquatic insects. However, aquatic life criteria are based on the fifth centile of sensitive genera to ensure the broad aquatic community, including emerging aquatic insects, are adequately protected. Aquatic insects ranked among the most tolerant taxa to acute ammonia exposures (Table 2-1). The data suggest that emergent insects will not be affected by the acute criteria, which are between 1-2 orders of magnitude below the species' GMAVs.

Chronic toxicity data related to emergent aquatic insects were relatively limited; however, an insect represented the most tolerant genus to chronic ammonia exposures (*Pteronarcella* genus mean chronic value [GMCV] = 73.74 mg/L, normalized to pH 7 and 20°C).

In addition to emergent aquatic insects, the Northern long-eared bat also relies heavily on terrestrial insects as a primary food source. In general, a number of studies indicate that terrestrial insects make up a greater percentage of the bat's diet, depending on the location (USFWS 1999, USEPA 2016). Terrestrial insects will not be affected at all by the new criteria.

Table 2-1. Acute insect toxicity data used to derive the acute ammonia criterion. Note, 69 GMAVs were available to derive the acute criterion, with insects ranking among the least sensitive taxa.

Genus	Genus Mean Acute Value (mg/L)[a]	Genus Rank in SSD
Erythromma (insect)	2,515	69
Philarctus (caddisfly)	994.5	68
Stenelmis (beetle)	735.9	67
Chironomus (midge)	681.8	65
Drunella (mayfly)	442.4	64
Callibaetis (mayfly)	246.5	60
Pachydiplax (dragonfly)	233.0	59
Skwala (stonefly)	192.4	52
Enallagma (damselfly)	164.0	47

[a] Normalized to pH 7 and 20°C (USEPA 2013).

Bats may also ingest ammonia through drinking water; however, this is not considered to be a meaningful route of exposure to elicit adverse effects in bats because the ammonia criteria are based on water-column exposures where the most sensitive route of exposure occurs at the gills, which does not apply to terrestrial species. Adverse effects typically result from an imbalance between internal and external ammonia concentrations. Ammonia is produced naturally in internal tissues, and organisms have natural mechanisms for excreting ammonia. Ammonia ingested by bats will be excreted through natural mechanisms (e.g., urine). Ammonia becomes toxic when the surrounding environment contains a high enough level that excretion mechanisms must work against a gradient that results in the organism being unable to excrete the excess ammonia (EPA 2013). This situation does not apply to terrestrial species which are not surrounded by environmental ammonia.

Therefore, because criteria are implemented conservatively, derived to protect the broad aquatic community (including emergent insects), and the bat's prey items are insensitive to ammonia, EPA's approval of Maine's acute and chronic freshwater ammonia standards may affect, but is Not Likely to Adversely Affect (NLAA), the Northern long-eared bat through effects on its prey or ingesting drinking water. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from ingesting prey or drinking water to the bat are insignificant.

2.3 Furbish's lousewort (*Pedicularis furbishiae*)

2.3.1 Furbish's Lousewort Ammonia Effects Assessment: Freshwater

With regard to Furbish's lousewort, as part of the development of the new ammonia criteria, EPA reviewed available data on the sensitivity of aquatic plants to ammonia, especially with regard to their comparative sensitivity with aquatic animals. EPA (USEPA 2013) found that data regarding the toxicity of ammonia to vascular plants indicated that aquatic plants appear to be two orders of magnitude less sensitive than the aquatic animals tested. Consequently, EPA assumes that ammonia criteria that protect aquatic animals will also protect aquatic plants (USEPA 1985, 1999, 2009), and EPA therefore finds that Maine's ammonia criteria may affect, but is Not Likely to Adversely Affect (NLAA) Furbish's lousewort through the effects of residential exposure. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from residential exposure to the lousewort are insignificant.

2.4 Eastern prairie fringed orchid (*Platanthera leucophaea*)

2.4.1 Eastern prairie fringed orchid Ammonia Effects Assessment: Freshwater

With regard to Eastern prairie fringed orchid, as part of the development of the new ammonia criteria, EPA reviewed available data on the sensitivity of aquatic plants to ammonia, especially with regard to their comparative sensitivity with aquatic animals. EPA (USEPA 2013) found that data regarding the toxicity of ammonia to vascular plants indicated that aquatic plants appear to be two orders of magnitude less sensitive than the aquatic animals tested. Consequently, EPA assumes that ammonia criteria that protect aquatic animals will also protect aquatic plants (USEPA 1985, 1999, 2009), and EPA therefore finds that Maine's ammonia criteria may affect, but is Not Likely to Adversely Affect (NLAA) Eastern prairie fringed orchid through the effects of residential exposure. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from residential exposure to the orchid are insignificant.

2.5 Piping Plover (*Charadrius melodus melodus*)

2.5.1 Piping Plover Ammonia Effects Assessment: Freshwater

The threatened Atlantic coast population of piping plover will not be meaningfully exposed to ammonia through residential exposure. As a result, EPA's approval action will have no meaningful residential exposure effects on Atlantic coast piping plover. Piping plovers that breed on the Atlantic Coast of the United States and Canada belong to the subspecies, *Charadrius melodus melodus* (USFWS 2015c). Intertidal areas provide key foraging habitats for over-wintering, non-breeding piping plover. Feeding areas include intertidal portions of ocean beaches; washover areas; mudflats; sandflats; wrack lines; and shorelines of coastal ponds, lagoons, or salt marshes where plovers prey on invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks (USFWS 1996). Because piping plover prey items are primarily marine/estuarine organisms, EPA approval of Maine's acute and chronic freshwater ammonia standards may affect, but is Not Likely to Adversely Affect (NLAA) Atlantic coast piping plover through effects on its prey. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from ingesting prey to the plover are insignificant.

2.6 Red Knot (*Calidris canutus rufa*)

2.6.1 Red Knot Ammonia Effects Assessment: Freshwater

The red knot will not be meaningfully exposed to ammonia through direct exposure and EPA's approval action will, therefore, have no meaningful residential exposure effect on the red knot. However, when red knots migrate between summer and wintering grounds, they often cross and rest at critical stopover areas (USFWS 2013a). For much of the year red knots eat small clams, mussels, snails and other invertebrates. In spring, migrating red knots appear to follow a northward "wave" in quality prey and time their stopovers with the spawning seasons of readily digestible food resources like juvenile clams and mussels and horseshoe crab eggs (USFWS 2013a). Because these red knot prey items are primarily marine/estuarine organisms, EPA approval of Maine's acute and chronic freshwater ammonia standards may affect, but is Not Likely to Adversely Affect (NLAA) red knot through effects on its prey. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from ingesting prey to the red knot are insignificant.

2.7 Roseate Tern (Sterna dougallii dougallii)

2.7.1 Roseate Tern Ammonia Effects Assessment: Freshwater

The roseate tern will not be meaningfully exposed to ammonia through direct exposure and EPA's approval action will, therefore, have no meaningful residential exposure effect on the roseate tern. Roseate terns feed on a variety of small schooling marine fish species, which have no exposure to the freshwater environment. Consequently, because the roseate tern prey items are primarily marine/estuarine organisms, EPA approval of Maine's acute and chronic freshwater ammonia standards may affect, but is Not Likely to Adversely Affect (NLAA) the roseate tern through effects on its prey. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from ingesting prey to the tern are insignificant.

2.8 Sea Birds

2.8.1 Sea Birds Ammonia Effects Assessment: Ingesting Drinking Water

The three species of sea birds discussed above – the piping plover, red knot and roseate tern- may also ingest ammonia through the water they drink; however, this is not considered to be a meaningful route of exposure to elicit adverse effects in birds because the ammonia criteria are based on water-column exposures where the most sensitive route of exposure occurs at the gills, which does not apply to terrestrial species. Adverse effects typically result from an imbalance between internal and external ammonia concentrations. Ammonia is produced naturally in internal tissues and organisms have natural mechanisms for excreting ammonia. Ammonia ingested by birds will be excreted through natural mechanisms (e.g., urine). Ammonia becomes toxic when the surrounding environment contains a high enough level that excretion mechanisms must work against a gradient that results in the organism being unable to excrete the excess ammonia (EPA 2013). This situation does not apply to terrestrial species which are not surrounded by environmental ammonia.

Based on the analysis above and because criteria are implemented conservatively, EPA's approval of Maines's acute and chronic freshwater ammonia standards may affect, but is Not Likely to Adversely Affect (NLAA) the three species of sea birds through ingesting drinking water. As such, the effects of approval of the freshwater ammonia water quality standards are too small to be detected and thus any effects from drinking water to the birds are insignificant.

2.9 Atlantic salmon (*Salmo salar*)

2.9.1 Atlantic salmon Ammonia Effects Assessment: Freshwater

As discussed above, Maine has proposed freshwater ammonia aquatic life criteria consistent with EPA's 2013 criteria recommendations, which reflect the latest scientific knowledge. Literature searches for laboratory toxicity tests of ammonia on freshwater aquatic life, published from 1985 to 2012, identified new studies containing acute and chronic toxicity data acceptable for criteria derivation. The acute criterion dataset includes 12 species of aquatic animals that are Federally-listed as threatened, endangered or species of concern. In the chronic criterion dataset for ammonia, Federally-listed species are represented by three salmonid fish species in the genus *Oncorhynchus*, including sockeye salmon, rainbow trout/steelhead, and the subspecies Lahontan cutthroat trout.

EPA's 1999 recommended aquatic life criteria for ammonia were based on the most sensitive endpoints known at the time. The acute criterion was based primarily on effects on salmonids (where present) or other fish, and the chronic criterion was based primarily on reproductive effects on the benthic invertebrate *Hyalella* or on survival and growth of fish early life stages (when present), depending on temperature and season.

The 2013 recommended criteria take into account data for several sensitive freshwater mussel species in the Family Unionidae that had not previously been tested. The 2013 criteria include additional data confirming the sensitivity of freshwater non-pulmonate snails. As noted in the 2013 document (USEPA 2013), approximately one-quarter of 300 freshwater unionid mussel taxa in the United States are Federally-listed as endangered or threatened species. Freshwater mussels are broadly distributed across the U.S., as are freshwater non-pulmonate snails, another sensitive invertebrate taxon, and both of these groups are now included in the ammonia dataset. The dataset used to derive the 2013 ammonia criteria magnitudes included some threatened or endangered species, and EPA noted that none were the most sensitive of the species tested (USEPA 2013). Overall, the 2013 freshwater acute and chronic aquatic life criteria for ammonia will more fully protect the aquatic community than previous criteria.

The ammonia criteria magnitude is affected by pH and temperature. For example, at pH of 7 and temperature of 20°C, the 2013 acute criterion magnitude is 17 mg TAN/L and the chronic criterion magnitude is 1.9 mg TAN/L. At this pH and temperature, the 2013 chronic criterion magnitude is 2.4-fold lower than the 1999 chronic criterion magnitude. The acute criterion duration represents a one-hour average. The chronic criterion duration represents a 30-day rolling average with the additional restriction that the highest 4-day average within the 30 days be no greater than 2.5 times the chronic criterion magnitude. These values are not to be exceeded more than once in 3 years on average.

Elevated ammonia levels in fish leads to labored respiration, convulsion, coma, and death. Toxicity in fish can either impair ammonia excretion or cause a net uptake of ammonia (Randall and Tsui 2002). Finn (2007) provides a review on the existing physiological and toxicological knowledge of salmonid eggs and larvae in relation to water quality. Among the effects discussed, Finn (2007) noted that excess ammonia penetration of developing embryo tissue could lead to teratogenic effects, or be detrimental to cell-to-cell signaling and formation of the central nervous system. At a molecular level, Kolarevic et al. (2012) were the first to report on the effects of long-term exposure (105 days) to ammonia on the genes encoding transport proteins for ammonia and urea. This study suggested that Atlantic salmon parr could adapt to long-term (sublethal) ammonia exposure by ammonia detoxification in the brain and an increased capacity for gill excretion of ammonia and urea provided through increased transcription of their transport proteins.

Knoph (1992) examined the acute toxicity of ammonia to Atlantic Salmon parr and the results of 96 hour mean LC 50 were 319.1 mg/L TAN and 364.5 mg/L TAN at mean temperatures of 2.1 ºC and 17.1ºC, respectively. In Atlantic salmon smolts, Alabaster et al. (1979 and 1983) found the 24 hour LC50 of un-ionized ammonia was approximately 0.15 mg/L NH_3 and 0.20 mg/L NH_3, respectively. EPA estimated the species mean acute value for ammonia toxicity in Atlantic salmon of 183.3 mg/L TAN, and a chronic toxicity value >30.64 mg/L TAN, both adjusted to pH7 (USEPA 2013).

Understanding that ammonia toxicity may have an adverse effect on all life stages of Atlantic salmon, and based on the information presented, the proposed freshwater ammonia criteria will afford additional protection to the listed species. EPA concludes that the proposed freshwater ammonia criteria may affect, but are Not Likely to Adversely Affect (NLAA) the Atlantic Salmon. Because any effects of the approval of the freshwater ammonia water quality criteria are extremely unlikely to occur, they are discountable.

In addition, in 2016 EPA consulted with FWS and NOAA Fisheries on the potential effects of federally promulgated criteria for ammonia on Atlantic salmon, Atlantic sturgeon and shortnose sturgeon, as well as Critical Habitat for Atlantic salmon and Atlantic sturgeon in Tribal Waters in Maine. Based on the information in the Biological Assessment submitted to FWS and NOAA Fisheries at that time, EPA determined that the promulgation of the proposed aquatic life criteria for ammonia is not likely to adversely affect the listed species and associated Critical Habitat under the jurisdiction of FWS and NOAA Fisheries. FWS and NOAA concurred.

3 Cadmium Effects Assessment[1]

3.1 Canada Lynx (Lynx canadensis)

3.1.1 Canada lynx Cadmium Effects Assessment: Freshwater

Sample et al. (1996) has calculated NOAEL-based benchmarks for large herbivorous terrestrial mammals (e.g. the whitetail deer) as 4.132 mg/L (4,132 µg/L) cadmium in water based on the NOAEL value for cadmium in the rat (USEPA 2010). This is a thousand fold higher than the criterion value. Given the isolated areas where Canada lynx are known to occur and that are targeted for recovery, and that their diet is comprised largely of small terrestrial mammals, the exposure of the lynx to cadmium either in surface waters or through bioconcentration through the food chain is unlikely. Canada Lynx habitat is outside of areas impacted by cadmium discharges or impaired waterbody listings for cadmium.

Lynx may also ingest cadmium through the water they drink. Aquatic organisms are considered to be more sensitive to cadmium relative to birds and mammals (USEPA 2016), and birds and mammals are considered to be comparatively resistant to cadmium. Consequently, criteria that are protective of aquatic life are also considered to be protective of mammals and birds (including aquatic-dependent wildlife).

Therefore, EPA has determined that the approval of Maine's freshwater criteria for cadmium will have no effect on the Canada lynx or its critical habitat. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from ingesting drinking water to the lynx are insignificant.

3.2 Northern Long-Eared Bat (*Myotis septentrionalis*)

3.2.1 Northern Long-Eared Bat Cadmium Effects Assessment: Freshwater

EPA's BE for the Northern long-eared bat focuses below on the effects that the cadmium criteria could cause due to ingesting potentially contaminated prey and drinking water. Because the bats do not live in the water, EPA concludes there will be no effects as a result of meaningful residential exposure.

Bats consume some combination of terrestrial and aquatic insects. Studies indicate that the Northern long-eared bat (*Myotis septentrionalis*) prefers terrestrial over aquatic insects and prefers to forage in woodland over riparian areas when available (Sparks et al 2005, USEPA 2016). Lepidopterans and Coleopterans (beetles), primarily terrestrial species, make up the majority of the diet of the Northern long-eared bat (Brack and Whitaker 2001, Feldhammer et al 2009, Lee and McCracken 2004, Whitaker 2004).

The Northern long-eared bat relies in part on emergent aquatic insects as a dietary resource and may be affected if cadmium, at water column concentrations specified by the freshwater acute or chronic criteria magnitude and duration, were to adversely affect a large portion of emergent

[1] Maine has adopted the acute and chronic cadmium criteria for both freshwater and estuarine/marine waters. EPA did not assess effects of the acute and chronic estuarine/marine cadmium criteria on the Canada lynx and the Northern long-eared bat because these species will experience no meaningful exposure to direct or indirect effects of cadmium in estuarine/marine environments.

aquatic insects. However, aquatic life criteria are based on the fifth centile of sensitive genera to ensure the broad aquatic community, including emergent aquatic insects, are adequately protected. Aquatic invertebrates tend to store cadmium in a detoxified state in their body tissues (USEPA 2016), which effectively reduces the toxicity of the cadmium bats ingest with contaminated prey. Aquatic insects are ranked among the most tolerant taxa to acute cadmium exposures (Table 3-1). The data suggest that emergent insects will not be affected by the acute criteria, which are between 2-5 orders of magnitude below the species' GMAVs.

Table 3-1. Acute insect toxicity data used to derive the acute freshwater cadmium criterion.

Genus	Genus Mean Acute Value (µg/L)[ab]	Genus Rank in Species Sensitivity Distribution (SSD)
Chironomus (midge)	49,052	75
Rhithrogena (mayfly)	22,138	71
Sweltsa (stonefly)	>20,132	70
Hexagenia (mayfly)	7,798	63
Ephemerella (mayfly)	4,467	53
Arctopsyche (caddisfly)	>1,637	45
Baetis (mayfly)	350.4	32

[a] Normalized to a hardness of 100 mg/L, expressed as total cadmium (corresponding acute criterion magnitude = 1.9 µg/L total cadmium).
[b] 75 GMAVs were available to derive the acute criterion, with insects ranking among the least sensitive taxa.

Chronic toxicity data related to emergent aquatic insects were relatively limited; however, a midge ranked fourth most sensitive to chronic exposures (Chironomus GMCV = 2.0 µg/L total cadmium, normalized to hardness of 100 mg/L) (USEPA 2016). The midge GMCV (based on the 20% effects level, or EC_{20}) is greater than the corresponding chronic criterion magnitude (0.79 µg/L total Cd, hardness = 100 mg/L), ...”and a large portion of individuals (i.e., > 80%) are not anticipated to be affected if cadmium concentrations were hypothetically at the chronic criteria magnitude for extended time periods consistent with chronic toxicity tests (e.g., 28-60 days) in Maine freshwaters (which is not the anticipated effect of the criteria). Further, the midge chronic toxicity value was based on exposure durations that were significantly longer than the 4-day chronic criterion duration.

Consequently, aquatic macroinvertebrate populations should not be adversely affected by cadmium at criteria levels.

In addition to emergent aquatic insects, the Northern long-eared bat also relies heavily on terrestrial insects as a primary food source. In general, a number of studies indicate that terrestrial insects make up a greater percentage of the bat's diet, depending on the location (USFWS 1999, USEPA 2016). Terrestrial insects will not be affected at all by the new criteria.

Bats may also ingest cadmium through the water they drink. Aquatic organisms are considered to be more sensitive to cadmium relative to birds and mammals (USEPA 2016), and birds and mammals are considered to be comparatively resistant to cadmium. Consequently, criteria that are protective of aquatic life are also considered to be protective of mammals and birds (including aquatic-dependent wildlife).

Based on the analysis above and because criteria are implemented conservatively and derived to protect the broad aquatic community (including emergent insects), EPA's approval of Maine's acute and chronic freshwater cadmium standards may affect, but is Not Likely to Adversely Affect (NLAA) the Northern long-eared bat through its prey or ingesting drinking water. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from ingesting prey or drinking water to the bat are insignificant.

3.3 Furbish's lousewort (*Pedicularis furbishiae*)

3.3.1 Furbish's lousewort Cadmium Effects Assessment: Freshwater

Furbish's lousewort is an herbaceous perennial plant that occurs on the intermittently flooded, ice-scoured banks of the Saint John River in northern Maine (USFWS 2018). Consequently, Furbish's lousewort may be exposed to cadmium in Maine freshwaters. Overall, aquatic plants are comparatively less sensitive than freshwater animals. As part of the development of the new cadmium criteria, USEPA (2016) states, "*Available data for aquatic plants and algae were reviewed to determine if they were more sensitive to cadmium than aquatic animals…. Effect concentrations for freshwater plants and algae were well above the freshwater criteria*" (p. 64). The cadmium effect concentrations for most freshwater aquatic plants and algae were above 50 ug/l and no growth effects on vascular plants were observed below 10 ug/l.

Appendix E of USEPA (2016) summarizes acceptable freshwater toxicity data for plants. Because plants are less sensitive to cadmium exposures than animals, and the acute and chronic cadmium criteria are based on animal responses, plants are not expected to be sensitive to cadmium at acute and chronic criteria concentrations. Consequently, cadmium criteria that protect aquatic animals should also protect aquatic plants. Therefore, approval of Maine's cadmium criteria is not likely to adversely affect Furbish's lousewort through the effects of residential exposure. Additionally, aquatic life criteria are based on the fifth centile of sensitive genera to ensure the broad aquatic community is adequately protected, maintaining ecosystem structure and function. Because criteria are protective of the broad aquatic community, approval of Maine's cadmium criteria may affect but is not likely to adversely affect Furbish's lousewort through residential exposure. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from residential exposure to the lousewort are insignificant.

3.4 Eastern prairie fringed orchid (*Platanthera leucophaea*)

3.4.1 Eastern prairie fringed orchid Cadmium Effects Assessment: Freshwater

Eastern prairie fringed orchid grows in wetlands such as sedge meadows, marsh edges, and bogs (USFWS 2020). Consequently, Eastern prairie fringed orchid may be exposed to cadmium in Maine freshwaters. Overall, aquatic plants are comparatively less sensitive than freshwater animals. As part of the development of the new cadmium criteria, USEPA (2016) states, "*Available data for aquatic plants and algae were reviewed to determine if they were more sensitive to cadmium than aquatic animals…. Effect concentrations for freshwater plants and algae were well above the freshwater criteria*" (p. 64). The cadmium effect concentrations for most freshwater aquatic plants and algae were above 50 ug/l and no growth effects on vascular plants were observed below 10 ug/l.

Appendix E of USEPA (2016) summarizes acceptable freshwater toxicity data for plants. Because plants are less sensitive to cadmium exposures than animals, and the acute and chronic cadmium criteria are based on animal responses, plants are not expected to be sensitive to cadmium at acute and chronic criteria concentrations. Consequently, cadmium criteria that protect aquatic animals should also protect aquatic plants. Therefore, approval of Maine's cadmium criteria is not likely to adversely affect the Eastern prairie fringed orchid through the effects of residential exposure. Additionally, aquatic life criteria are based on the fifth centile of sensitive genera to ensure the broad aquatic community is adequately protected, maintaining ecosystem structure and function. Because criteria are protective of the broad aquatic community, approval of Maine's cadmium criteria may affect but is not likely to adversely affect the Eastern prairie fringed orchid through residential exposure. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from residential exposure to the orchid are insignificant.

3.5 Piping Plover (*Charadrius melodus melodus*)

3.5.1 Piping Plover Cadmium Effects Assessment: Freshwater and Estuarine/Marine

The piping plover (Atlantic Coast population) will not be meaningfully exposed to cadmium through direct exposure. As a result, EPA's approval action will have no meaningful residential exposure effect on the piping plover. However, the piping plover relies on freshwater and estuarine/marine invertebrates as its prey base and may be affected if cadmium, at water column concentrations specified by the acute and chronic criteria magnitudes and durations, were to adversely affect a large portion of the prey items.

Piping plovers feed in many habitat types within their breeding and wintering areas, including wet sand in the wash zone, inter-tidal ocean beach, wrack lines, washover passes, mud, sand and algal flats, and shorelines of streams, ephemeral ponds, lagoons, and salt marshes (USFWS 1996). Piping plovers feed primarily on invertebrates that are 1/2 inch or less below the surface on exposed beach surfaces. They feed mostly during the day and eat insects, marine worms, crustaceans, and mollusks as well as eggs and larvae of flies and beetles (USFWS 1996). Where piping plovers forage depends on what habitats are available to them, the amount of prey, proximity of foraging areas to nest sites, and the amount of human disturbance.

Only fish are among the most sensitive taxa to acute cadmium exposures in freshwaters, with invertebrates, including piping plover prey items, being more tolerant. The freshwater chronic cadmium criterion and saltwater acute and chronic cadmium criteria include benthic (*Hyalella*, freshwater chronic criterion) and pelagic crustaceans (*Neomysis*, *Tigriopus*, *Americamysis*; saltwater acute and chronic criteria) and at least one aquatic insect (*Chironomus*, freshwater chronic criterion) among the most sensitive taxa to cadmium exposure. Effects to these sensitive crustacean and aquatic insect populations, however, are expected to be minimal because criteria are derived to protect the fifth centile of the most sensitive genera. Further, any effects to these piping plover prey items would translate minimally to the piping plover because piping plovers do not rely exclusively on these species as a food source, with additional food sources [e.g., other insects (including terrestrial), benthic worms, and mollusk populations] remaining tolerant to cadmium exposures (USEPA 2016). As a result, EPA approval of Maine's acute and chronic freshwater and saltwater cadmium standards may affect, but is Not Likely to Adversely Affect (NLAA) piping plover through its prey. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from ingesting prey to the plover are insignificant.

3.6 Roseate Tern (*Sterna dougallii dougallii*)

3.6.1 Roseate Tern Cadmium Effects Assessment: Estuarine/Marine

The roseate tern will not be meaningfully exposed to cadmium through direct exposure. As a result, EPA's approval action will have no meaningful residential exposure effect on the roseate tern. However, the roseate tern relies on marine fishes as a primary dietary resource and may be affected if cadmium, at water column concentrations specified by the cadmium criteria magnitudes and durations, were to adversely affect a large portion of the saltwater fishes the roseate tern commonly relies on as a dietary resource.

Roseate terns feed on a variety of small schooling marine fish species such as young mackerel, Atlantic silversides (*Menidia menidia*), and sardines (*Sardinella* sp.), usually when predatory species chase prey fish near the sea surface (USFWS 2010). Studies of chick provisioning by roseate terns in the Northeast population indicate that the predominant prey species in the diet were American sand lance (*Ammodytes americanus*), hake spp., and Atlantic herring (*Clupea harengus*). The majority of estuarine/marine fish are insensitive acute cadmium exposure, with the *Morone* GMAV (GMAV = 75 µg/L; genus rank in SSD = 5) the most sensitive marine fish to acute cadmium exposures (Table 3-2).

Table 3-2. Acute toxicity data for Atlantic coast estuarine/marine fishes used to derive the estuarine/marine acute cadmium criterion. Note, 79 GMAVs were available to derive the acute criterion.

Genus	Genus Mean Acute Value (µg/L)	Genus Rank in SSD
Cyprinodon	28,196	75
Tautogolabrus	25,900	74
Fundulus	19,550	70

Pseudopleuronectes	14,297	68
Mugil	9,217	61
Menidia	1,054	33
Lagodon	1,000	31
Morone	75.0	5

Given the tolerance of most marine fish to cadmium exposure, it is not likely that roseate tern will experience any appreciable effects of cadmium *in situ.* EPA approval of Maine's acute and chronic estuarine/marine cadmium standards may affect, but is Not Likely to Adversely Affect (NLAA) the roseate tern through its prey. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from ingesting prey to the tern are insignificant.

3.7 Red Knot (*Calidris canutus rufa*)

3.7.1 Red Knot Cadmium Effects Assessment: Freshwater and Estuarine/Marine

The red knot will not be meaningfully exposed to cadmium through direct exposure. As a result, EPA's approval action will have no meaningful residential exposure effect on the red knot. However, the red knot relies on estuarine/marine invertebrates as its prey base and may be affected if cadmium, at water column concentrations specified by the acute and chronic criteria magnitudes and durations, were to adversely affect a large portion of the prey items.

Information on the abundance and locations of spring and fall migrating red knots that stopover in Maine is limited. During migration, red knots may converge on critical stop over areas or may be found in small numbers scattered along the NH coast to rest and forage before resuming their migration (vonOettingen 2019). For much of the year red knots eat small clams, mussels, snails and other invertebrates. In spring, migrating knots appear to follow a northward "wave" in quality prey and time their stopovers with the spawning seasons of readily digestible food resources like juvenile clams and mussels and horseshoe crab eggs.

Estuarine and marine mussels, clams and crabs are not among the most sensitive taxa to cadmium exposure (Table 3-3; USEPA 2016), and because criteria are derived to protect the broad aquatic community (including marine mollusks and crustaceans), EPA approval of Maine's acute and chronic freshwater and saltwater cadmium standards may affect, but is Not Likely to Adversely Affect (NLAA) red knot through effects on its prey. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from ingesting prey to the red knot are insignificant.

Table 3-3. Acute toxicity data for estuarine/marine mussels and clams used to derive the estuarine/marine acute cadmium criterion. Note, 79 GMAVs were available to derive the acute criterion.

Genus	Genus Mean Acute Value (µg/L)	Genus Rank in SSD
Perna (mussel sp.)	1,506	38
Mytilus (mussel sp.)	736.2	25
Isognomon (oyster sp.)	422.6	19
Tresus (clam sp.)	188.1	10
Crassostrea (oyster sp.)	173.2	9

3.8 Sea Birds

3.8.1 Sea Birds Cadmium Effects Assessment: Ingesting Drinking Water

The three species of sea birds, above, may also ingest cadmium through the water they drink. Aquatic organisms are considered to be more sensitive to cadmium relative to birds and mammals (USEPA 2016), and birds and mammals are considered to be comparatively resistant to cadmium. Consequently, criteria that are protective of aquatic life are also considered to be protective of mammals and birds (including aquatic-dependent wildlife).

Based on the analysis above and because criteria are implemented conservatively, derived to protect the broad aquatic community (including emergent insects), EPA's approval of Maine's acute and chronic freshwater cadmium standards may affect, but is Not Likely to Adversely Affect (NLAA) the three species of sea birds through ingesting drinking water. As such, the effects of approval of the freshwater cadmium water quality standards are too small to be detected and thus any effects from drinking water to the birds are insignificant.

3.9 Atlantic salmon (*Salmo salar*)

3.9.1 Atlantic salmon Cadmium Effects Assessment: Freshwater

3.9.1.1 Identifying Salmon Acute Cadmium Data

Species-level acute data were not available for Atlantic salmon for this analysis. Therefore, genus-level acute toxicity data were obtained from Appendix A of USEPA (2016) to represent the sensitivity of Atlantic salmon to acute cadmium exposures. The GMAV for Atlantic salmon is based on a single SMAV for the brown trout (*Salmo trutta).* The SMAV is composed of a single LC_{50} value of 5.642 µg/L, normalized to a total hardness of 100 mg/L as $CaCO_3$. The SMAV value is based on the geometric mean of five 96-h LC50s (Davies and Brinkman, 1994c; Brinkman and Hansen, 2004a, 2007; Stubblefield, 1990). The toxicity tests were carried out using flow-through exposures and fingerling or fry life stages (results presented in Table 3-4 below).

Table 3-4. Data used to calculate the Brown trout GMAV acute sensitivity to cadmium.

Species	Normalized Acute Value (µg/L)	GMAV (µg/L)[a]	Reference
Brown trout (fingerling) *Salmo trutta*	5.845	5.642	Stubblefield 1990
Brown trout (fingerling) *Salmo trutta*	6.173		Davies and Brinkman 1994c
Brown trout (fry) *Salmo trutta*	4.104		Brinkman and Hansen 2004a; 2007
Brown trout (fry) *Salmo trutta*	5.721		Brinkman and Hansen 2004a; 2007
Brown trout (fry) *Salmo trutta*	6.746		Brinkman and Hansen 2004a; 2007

[a] Normalized to a hardness of 100 mg/L as $CaCO_3$ (USEPA 2016).

3.9.1.2 Deriving LC_{50} to LC_5 Acute Adjustment Factor

EPA obtained and analyzed raw C-R data based on TRAP models for all tests used to derive the acute criterion (*Appendix_ME.Cadmium_C_R_Data*). As Atlantic salmon C-R data were not available, C-R data were available for two tests with brown trout, a genus-level surrogate. Of the two C-R curves, Cd-Acute-76 was the only acceptable model fit with an LC50:LC5 ratio of 2.797 µg/L. Cd-Acute-77 was not used because there were no low-level responses to accurately characterize low effect levels such as the LC5. Nevertheless, Cd-Acute-77 resulted in an LC50:LC5 ratio of 1.740 µg/L, which is significantly less than 2.797 µg/L, indicating application of 2.797 µg/L (genus level TAF) to transform the Atlantic salmon LC50 into an LC5 may result in a relatively conservative LC5 estimate (i.e., dividing the LC50 by a relatively large LC50:LC5 ratio produces a relatively low LC5).

3.9.1.3 Calculating Atlantic Salmon Acute Cadmium Low Effect Threshold

Dividing the brown trout LC_{50} value (5.642 µg/L; genus-level surrogate value for Atlantic salmon) by the genus-level TAF (2.797) results in an acute cadmium low effect threshold concentration (LC5) of 2.017 µg/L. Typically, minimum effect threshold concentrations are compared to corresponding criteria magnitudes (i.e., criterion maximum concentration, CMC) under reference water chemistry (i.e., the water chemistry that all acute LC50 data were normalized to in Appendix A of (USEPA, 2016). For most aquatic life criteria, results of the comparison in reference waters are applicable to all water chemistries because the criteria magnitudes and species sensitivity vary proportionally across all water chemistries. However, because Maine implements metals criteria using a default hardness input value of 20 mg/L, EPA calculated the acute criterion that would apply under all hardness conditions in Maine, 0.393 ug/L. The CMC was then compared to the Atlantic salmon acute low effect threshold (i.e., LC5) renormalized to ambient hardness conditions in Maine to account for cadmium's varying toxicity with hardness.

To normalize to actual hardness conditions observed, data was pulled from U.S. Geological Survey (USGS)'s National Water Information System (NWISweb) in Atlantic salmon critical habitat (site #s 1022250, 1022260, 1022500, 1034500, 1036390, 1046500, 1049265, 1059000, 1059400, 444150067493900, 444238067512100, 453015069210601). The LC5 value (2.017 µg/L) was renormalized to the actual hardness data in Maine using the following equation:

LC5 at hardness B = EXP(LN(LC5 at hardness A)-(0.9789*(LN(hardness A)-LN(hardness B))))

where hardness A = LC5 at hardness 100 mg/L = 2.017 and hardness B = the actual hardness based on NWISweb data

3.9.1.4 Salmon: Acute Cadmium Effects Determination

In Maine, the cadmium criteria is calculated at hardness of 20 mg/L which corresponds to a CMC of 0.393 µg/L for total cadmium. EPA evaluated the percent of the time, based on available hardness data, the CMC was greater than the renormalized LC5 to inform the final effects determination. The results showed that the CMC at a hardness of 20 mg/L was greater than the renormalized LC5 68.7% of the time, i.e. that the CMC may not protect Atlantic salmon under 68.7% of observed water hardness conditions in Maine. When the measured water hardness dropped below 19 mg/L the CMC was above the LC5 threshold.

Next, EPA evaluated the effect of the state's 20 mg/L hardness requirement on the calculated CMC relative to Atlantic salmon acute sensitivity. Instead of using a hardness default of 20 mg/L in the acute criterion calculation, a CMC was calculated for each hardness data value obtained from USGS and compared to the LC5 value at the equivalent hardness. When the hardness requirement was removed, the cadmium criteria was protective of Atlantic salmon 100% of the time. This demonstrates that the acute cadmium criterion currently before EPA for action protects Atlantic salmon.

The chronic cadmium effects determination (see below) showed the chronic criterion protects Atlantic salmon under 97% of observed water hardness conditions in Maine. The chronic criterion is also more stringent than the acute criterion, and it therefore typically supersedes the acute in practical application, including MDPES permits and waterbody attainment decisions. Therefore EPA anticipates the salmon will be protected in practice because both criteria are applied to every water body. Maine also allows flexibility in permitting situations to allow for recalculation of criteria based on actual ambient physical water characteristics (06-906 CMR 530 (4)(D)). In addition, the EPA has recently encouraged Maine to remove its hardness requirement[2]. Therefore, the cadmium criterion may affect, but is not likely to adversely affect (NLAA) Atlantic salmon. Because any effects of the approval of the freshwater acute cadmium water quality criteria are extremely unlikely to occur, they are discountable.

[2] April 22, 2020 letter from Ralph Abele, Chief, Water Quality Standards Section, U.S. EPA Region 1 to Susanne Meidel, Water Quality Standards Coordinator, Maine Department of Environmental Protection.

3.9.2 Salmon Chronic Cadmium Effects Assessment: Freshwater

3.9.2.1 Identifying Salmon Chronic Cadmium Data

Species-level chronic data were available for Atlantic salmon for this analysis. The SMCV for Atlantic salmon is 2.389 µg/L (hardness = 100 mg/L; total Cd). This value is based on a single study evaluating growth from an early life stage test from fertilization to near complete yolk absorption (Rombough and Garside, 1982).

3.9.2.2 Deriving EC20 to EC5 Chronic Adjustment Factor

EPA obtained and analyzed raw C-R data for all tests used to derive the chronic criterion (USEPA 2016 Appendix C underlined values) where such data were reported or could be obtained to derive a chronic TAF. Overall, there were three C-R curves available for Atlantic salmon; however, none of the three (i.e., Cd-Chronic-35, Cd-Chronic-36, and Cd-Chronic-37) produced acceptable model fits. As a result, the only acceptable model fit from a genus-level surrogate, brown trout, was used to derive a representative EC20:EC5 ratio of 1.229. This ratio is significantly lower than all three ratios (range = 3.466 to 8.292) from the unacceptable Atlantic salmon curves.

3.9.2.3 Calculating Salmon Chronic Cadmium Low Effect Threshold

Dividing the Atlantic salmon EC_{20} value (2.389 µg/L) by the EC20:EC5 ratio (1.229) results in a chronic low effect threshold concentration of 1.943 µg/L (normalized to a hardness of 100 mg/L as $CaCO_3$).

Consistent with the acute effects assessment, EPA calculated the chronic criterion that would apply under all hardness conditions in Maine under the State's 20 mg/L hardness requirement, and compared the resulting CCC, 0.219 µg/L, to the Atlantic salmon chronic low effect threshold (i.e., EC5) renormalized to ambient hardness conditions in Maine to account for cadmium's varying toxicity with hardness. To normalize to actual hardness, data was pulled from U.S. Geological Survey (USGS)'s National Water Information System (NWISweb) in Atlantic salmon critical habitat (site #s 1022250, 1022260, 1022500, 1034500, 1036390, 1046500, 1049265, 1059000, 1059400, 444150067493900, 444238067512100, 453015069210601). The EC5 value was renormalized to the actual hardness data in Maine using the following equation:

EC5 at hardness B = EXP(LN(EC5 at hardness A)-(0.7977*(LN(hardness A)-LN(hardness B))))

where hardness A = EC5 at hardness 100 mg/L = 1.943 and hardness B = measured hardness data from NWISweb

3.9.2.4 Salmon: Chronic Cadmium Effects Determination

In Maine, the cadmium criteria is calculated at hardness of 20 mg/L which corresponds to a CCC of 0.219 µg/L for total cadmium. The cadmium CCC is over 8.9 times lower than the salmon chronic cadmium low effect threshold concentration of 1.943 µg/L total cadmium (normalized to hardness of 100 mg/L).

The percent of the time the CCC was greater than the renormalized EC5 across varying ambient hardness conditions observed in Maine was evaluated to determine the final effect determination. The results showed that the CCC was greater than the renormalized EC5

3.16% of the time when adjusted for measured water hardness in the critical salmon habitat. When the hardness dropped below 7 mg/L, the 5% chronic effects threshold was exceeded. To evaluate the effects of the state's 20 mg/L hardness requirement on the CCC, relative to Atlantic salmon chronic sensitivity, a paired CCC was calculated for each hardness data value and compared to the EC5 value at the equivalent hardness. When the hardness requirement was removed, the cadmium CCC was protective of Atlantic salmon 100% of the time. These two analyses suggest that the chronic cadmium criterion may affect, but is not likely to adversely affect (NLAA) Atlantic salmon. Because any effects of the approval of the freshwater chronic cadmium water quality criteria are extremely unlikely to occur, they are discountable.

3.9.3 Salmon Cadmium Prey Effects Assessment

Salmon are not specific feeders and rely on a wide range of benthic invertebrates and fishes. The most sensitive genera to acute cadmium exposures includes salmonids (*Oncorhynchus*, *Salvelinus* and *Salmo*), sculpin (*Cottus*), and striped bass (*Morone*; Table 7 of USEPA 2016), with pelagic crustaceans (*Hyalella* and *Ceriodaphnia*), sculpin (*Cottus*), and a midge (*Chironomus*) comprising the four most-sensitive genera to chronic exposures in freshwater (Table 9 of USEPA 2016). Even if certain components of Atlantic salmon diets were among the most sensitive genera, the salmon would not experience any appreciable prey effects because they are broad opportunistic feeders. Salmon consume a wide range of invertebrate taxa, which are adequately protected by the cadmium criteria, considering criteria are typically based on the fifth percentile of sensitive genera and implemented under conservative exposure conditions.

EPA approval of the freshwater (acute and chronic) cadmium criteria as Maine's water quality standards may affect, but is Not Likely to Adversely Affect (NLAA) Atlantic salmon through prey effects because: 1) criteria are implemented conservatively; 2) salmon prey items are relatively insensitive to cadmium compared to those genera that drive the criteria magnitudes; and 3) salmon are not specialized feeders relying on a specific prey item that may be affected by cadmium exposures. Also see Section 4.2, below, regarding salmon prey. As such, the effects of approval of the acute and chronic cadmium water quality standard are too small to be detected and thus any chronic acute prey effects to Atlantic salmon are insignificant.

4 Critical Habitat Analyses

4.1 Canada lynx (Lynx canadensis)

On February 25, 2009, U.S. Fish and Wildlife Service published a final revised rule designating critical habitat for the contiguous U.S. distinct population segment of Canada lynx, in five units in the States of Maine, Minnesota, Montana, Wyoming, Idaho, and Washington.. The rule became effective on March 27, 2009. Unit 1 is located in northern Maine in portions of Aroostook, Franklin, Penobscot, Piscataquis, and Somerset Counties.

The specific biological and physical features (PBFs), otherwise known as the primary constituent elements, essential to the conservation of the lynx are:

1. Boreal forest landscapes supporting a mosaic of differing successional forest stages and containing:

a. Presence of snowshoe hares and their preferred habitat conditions, which include dense understories of young trees, shrubs or overhanging boughs that protrude above the snow, and mature multistoried stands with conifer boughs touching the snow surface;

b. Winter snow conditions that are generally deep and fluffy for extended periods of time;

c. Sites for denning that have abundant coarse woody debris, such as downed trees and root wads; and

d. Matrix habitat (e.g., hardwood forest, dry forest, non-forest, or other habitat types that do not support snowshoe hares) that occurs between patches of boreal forest in close juxtaposition (at the scale of a lynx home range) such that lynx are likely to travel through such habitat while accessing patches of boreal forest within a home range.

The critical habitat designation is designed for the conservation of the physical and biological features essential to the conservation of the lynx and necessary to support lynx life history functions. The physical and biological features, described above, comprise the essential features of boreal forest that (1) provide adequate prey resources necessary for the persistence of local populations and metapopulations of lynx through reproduction; (2) act as a possible source of lynx for more peripheral boreal forested areas; (3) enable the maintenance of home ranges; (4) incorporate snow conditions for which lynx are highly specialized that give lynx a competitive advantage over potential competitors; (5) provide denning habitat; and (6) provide habitat connectivity for travel within home ranges, exploratory movements, and dispersal within critical habitat units. Lynx use habitat at a landscape scale, which means that no single locality (small scale) contains all of the required habitat elements that lynx need to ensure survival and reproduction. Therefore, individual portions of each unit (for example, an individual forest stand) may not contain all of the PBFs listed above, however, each unit, as a landscape, does contain each of the PBFs and it is the landscape as a whole that contains the PCE.

The proposed action is to approve revised water quality criteria for freshwater ammonia and cadmium. Changes in these chemical parameters will not affect PBFs 1 (a) – (d), which describe suitable weather (winter) and physical ecosystem conditions for forest composition and structure, and presence of specific species of wildlife (snowshoe hare) in suitable numbers.

Consequently, EPA finds that the proposed action will have No Adverse Modification on the Critical Habitat of the Canada lynx in the Action Area in Maine as described by PBFs 1 (a) – (d).

4.2 Atlantic salmon (Salmo salar)

On June 19, 2009, NOAA Fisheries published a final rule designating critical habitat areas for the Atlantic salmon. The critical habitat for the Atlantic salmon in the Gulf of Maine DPS encompass three Habitat Recovery Units in Maine: the Downeast Coastal Basin, Merrymeeting Bay, and the Penobscot Basin, which together comprise a large percent of the southern two thirds of the State of Maine. The rule became effective on July 20, 2009.

In the Gulf of Maine DPS, the following physical and biological features (PBFs) are identified as essential to the conservation of the species because they provide foraging area functions (74 FR 29299):

1) *Physical and Biological Features of the Spawning and Rearing PCE*
   a) *Deep, oxygenated pools and cover (e.g., boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall;*
   b) *Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development;*
   c) *Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development, and feeding activities of Atlantic salmon fry;*
   d) *Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr;*
   e) *Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production;*
   f) *Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr;*
   g) *Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.*
2) *Physical and Biological Features of the Migration PCE*
   a) *Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations;*
   b) *Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (e.g., boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon;*
   c) *Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation;*
   d) *Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment;*
   e) *Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration;*
   f) *Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.*

Parr feed on larvae of mayflies, stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks, as well as numerous terrestrial invertebrates that fall into the river (NOAA 2009). Sections 2.2 and 3.2 above, demonstrate that the prey of the Northern long-eared bat, which consists of similar insects and invertebrates, will not be adversely affected by ammonia and cadmium at criteria levels. Similarly, EPA's ESA consultation BE for Vermont's freshwater cadmium criteria (EPA 2020), excerpted in Appendix B, attached, and EPA's dwarf wedgemussel analysis for freshwater ammonia criteria, attached in Appendix C, demonstrate that the dwarf wedgemussel, among the most sensitive species of mollusk, will not be adversely affected by the same cadmium and ammonia criteria, respectively, in this consultation. In addition, "as parr grow, they will occasionally eat small fishes, such as alewives, dace, or minnows" (NOAA 2009). EPA assessed the effect of these pollutants on similar fish species in its analyses of the host fish for the dwarf wedgemussel and found they were not likely to adversely affect these fish species.   See Appendices B and C, attached. Consequently, changes in these chemical parameters will not affect PBF 1(g), which describes the desired condition of the salmon parr prey.

PBF 2(f) defines required water quality conditions for the salmon smolts, focusing on the need to avoid increased acidity and low pH conditions (NOAA 2009). The effect of changes in freshwater cadmium and ammonia concentrations, including the reduction of those levels through these revised water quality criteria, should have no effect on the acidity or pH of the smolts' aquatic environment.

Therefore, changes in these chemical parameters will not affect PBF 2(f), which describes suitable water chemistry conditions for the salmon smolts.

Consequently, EPA finds that the proposed action will have No Adverse Modification on the Critical Habitat of the Atlantic salmon in the Action Area as described by PBFs 1-2.

5 Final Effects Determinations

In conclusion, EPA has determined that EPA's approval of Maine's revised ammonia and cadmium criteria is not likely to adversely affect listed species, including the Canada lynx, Northern long-eared bat, piping plover, red knot, roseate tern Furbish's lousewort and Eastern prairie fringed orchid. Because the new criteria are more stringent than the current criteria, EPA's approval may in fact have a beneficial effect on the species compared to current conditions.

The Canada lynx, Northern long-eared bat, piping plover, red knot, Furbish's lousewort and Eastern prairie fringed orchid are insensitive to acute and chronic freshwater ammonia and freshwater cadmium exposures at the respective criteria magnitudes under the adopted water quality standards. The piping plover, red knot, and roseate tern are also insensitive to cadmium at acute and chronic criteria magnitudes in estuarine/marine waters under the adopted water quality standards. Listed species' prey items are insensitive to cadmium. Additionally, aquatic life criteria are implemented conservatively and are based on the fifth centile of sensitive genera and will, therefore, protect listed species prey items. As a result, approval of the acute and chronic ammonia (freshwater) and cadmium (freshwater and estuarine/marine) criteria as Maine state water quality standards is Not Likely to Adversely Affect (NLAA) aquatic and aquatic-dependent listed species through residential exposure, and effects on prey and ingesting drinking water (Table 5-1). EPA views the cadmium and ammonia criteria revisions as beneficial to the conservation and protection of aquatic life, including listed species and their food sources in Maine.

Table 5-1. Final effects determinations for cadmium and ammonia, for aquatic and aquatic-dependent listed species occurring in Maine that may be affected by the approval action.

Species	Final Effects Determination
Canada lynx (*Alasmidonta heterodon*)	***No Effect*** (residential exposure = no effect; other effects = no effect)
Northern Long-Eared Bat (*Myotis septentrionalis*)	***NLAA*** (Residential exposure = no effect; other effects = NLAA)
Furbish's lousewort *(Scirpus ancistrochaetus)*	***NLAA*** (residential exposure)
Eastern praire fringed orchid *(Scirpus ancistrochaetus)*	***NLAA*** (residential exposure)
Piping Plover (*Charadrius melodus melodus*)	***NLAA*** (Residential exposure = no effect; other effects = NLAA)
Red Knot (*Calidris canutus rufa*)	***NLAA*** (Residential exposure = no effect; other effects = NLAA)
Roseate Tern (*Sterna dougallii dougallii*)	***NLAA*** (Residential exposure = no effect; other effects = NLAA)
Atlantic salmon (*Salmo salar*)	***NLAA*** (Residential exposure)

6 References[3]

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[3] To facilitate comparison to the same references cited in EPA's aquatic life criteria documents for Ammonia (USEPA 2013) and Cadmium (USEPA 2016), the subscript lettering for select references in this document is the same as originally cited in the corresponding aquatic life criteria documents (e.g., Wang et al. 2014a in USEPA 2016).

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